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FISCAL YEAR 1976

Federal Plan for Marine Environmental Prediction

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND
ATMOSPHERIC ADMINISTRATION





U.S. DEPARTMENT OF COMMERCE

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FEDERAL COORDINATOR FOR MARINE ENVIRONMENTAL PREDICTION

INTERAGENCY COMMITTEE FOR MARINE ENVIRONMENTAL PREDICTION

FEDERAL PLAN FOR MARINE ENVIRONMENTAL PREDICTION

FISCAL YEAR 1976

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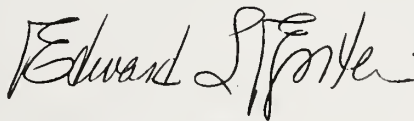
PREFACE

This Federal Plan is the fifth consecutive annual summary of Federal Marine Environmental Prediction (MAREP) Services and supporting research for the development of new or enhanced services. The purpose of the Plan is to provide a summary of Federal MAREP programs to Congressional staff, Government [and non-Government] agencies, and other organizations including industry. MAREP Services include a Basic Service and the Specialized MAREP Services for support of Maritime Commerce, Water Quality Assessment, Living Marine Resources, and National Security.

The principal tasks of coordinating Government MAREP activities and of preparing and maintaining the Federal Plan are performed by the Interagency Committee for Marine Environmental Prediction. This Committee and its subgroups conduct systematic reviews of basic and specialized marine monitoring and prediction techniques and services and of relevant research in support of MAREP. Long-range specialized plans in specified areas of MAREP that need improvement and coordination are also developed under the auspices of the Committee.

Identification of changes in responsibility and/or program priorities can be inferred from a review of increases and reductions in MAREP expenditures. The current trend is toward support of energy-related activities. An economic analysis of increases in the population, inflation, and in MAREP funding during the 6 years that MAREP activities have been identified, including fiscal year 1976 projections, reveals that only 34% of these expenditures provide new or increased MAREP services.

Foremost among new or expanded thrusts for fiscal year 1976 are Interior's continued expansion of Outer Continental Shelf (OCS) activities, operation of Commerce's reactivated research vessels and geostationary satellites and expanded marine resource surveys, and the National Science Foundation's increased funding for Arctic research.




Edward S. Epstein
Federal Coordinator for
Marine Environmental Prediction



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Frontispiece.—An environmental data buoy array will provide input to the Basic MAREP Service data acquisition system.



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Executive Summary

Man's increased use of the ocean has brought about a realization of its impact and need for accurate forecasting of the marine environment. These forecasts, generated through various forecast and prediction services, provide information and products to users in maritime commerce, recreational and commercial fisheries, regulation and protection of water quality, and the military.

The MAREP Services are categorized as Basic and Specialized. Basic MAREP Service provides observational data, their transmission and analysis, and processed advisories, warnings, or forecasts. Because of their fundamental nature most Basic Service data and products provide the foundation for the Specialized Services. These Specialized Services draw upon the data output of the Basic Service to generate products that will serve the operational needs of the particular user group. These Specialized MAREP Services include: Maritime Commerce, Living Marine Resource, Water Quality Assessment, and National Security. Research efforts are applied to the MAREP Services to improve both the Basic and Specialized Services.

Primary increases in MAREP expenditures in fiscal year 1976 result from expanded activities of the Department of the Interior on the outer Continental Shelf. The Department of Commerce reported increases, although on a reduced scale, through the reactivation of research vessels, support for geostationary satellites, and expanded resource surveys. The National Science Foundation also reported increases, primarily for their Arctic research program.

National or agency focus on operational services and research as reflected by funding trends shows only a small real increase. MAREP funding has increased 87%, from \$145.2 million to \$270.9 million, during the 5 years that MAREP funding has been identified. Projected fiscal year 1976 levels of \$315.9 million will result in a 118% increase for the 6-year period. Examination of population increases and inflation rates during 1971-76 reveals, however, that only 34% of this more-than-doubled funding was available for new or improved services.

The most significant trends are found in the redirection of National and agency goals. In 1971, when MAREP expenditures were first identified, the Department of Defense reported the largest percentage of the funding (fig. 39), followed by Commerce (NOAA), Transportation, and NSF. From 1971 through 1973 funding for the other member agencies remained essentially level, with only Commerce, now the lead agency, showing major increases. These increases were the result of a rapid growth by NOAA. A redirection of priorities in 1973 (fig. 39) brought about a reduction of Defense funding, level funding by Commerce and Transportation, and the initiation of a to be continuing (1973-76) increase by Interior. These increases are a reflection of the growing concern and focus toward energy exploration on the outer Continental Shelf. Projected fiscal year 1976 expenditures identify Commerce as the leading MAREP agency, followed by Interior, Defense, and NSF.

Introduction

Man is making increased use of the oceans as a means for seaborne commerce, a source of living resources, a sink for many of his wastes, and an important link in his defenses. He has been aware, since earliest times, of the consequences of operating at sea when conditions were severe; these conditions often arose unexpectedly while at sea. His inability to forecast the weather and ocean conditions in even near-shore regions has hampered his commerce, fisheries, and defense efforts.

Marine meteorological and oceanographic research has shown that forecasting of many marine environmental parameters is possible. Parallel research on biological resources and water quality assessment are also demonstrating that fluctuations can be related to the forecastable physical processes. These research efforts and accompanying development programs primarily conducted or funded by the U.S. Government support a variety of marine environmental monitoring, analysis, assessment, and prediction services which define the physical, chemical, and selected biological states of the ocean and its interaction with the overlying atmosphere and adjacent terrestrial boundaries. The need for coordinating these services and their research was recognized by the former Marine Science Council in 1969, and a lead agency role for coordinating national efforts in Marine Environmental Prediction (MAREP) was assigned to ESSA (now NOAA).

The Implementation Plan for performing this role included establishment of the Interagency Committee for Marine Environmental Prediction (ICMAREP) and the Federal Coordinator for MAREP. The Federal Coordinator is charged with the responsibility for preparing an annual Federal Plan for MAREP with the support of ICMAREP.

This Federal Plan summarizes the needs and objectives of MAREP, identifies activities of Federal agencies in MAREP, and discusses in detail the Basic and Specialized MAREP Services. In addition to descriptions of the existing MAREP Services, planned improvements through service expansion or relevant research are considered in the Plan, as are proposed funding increases. The Plan was first published in February 1971 for fiscal year 1972, and a new one has been produced annually ever since. This is the fifth such Plan.

Organization.—This fiscal year 1976 Federal Plan is structured to provide the reader ready access to descriptions of the various MAREP services, agency participation, and funding. The Basic MAREP Service is discussed by function: Data Acquisition, Communications, Data Processing, and Information Dissemination; and in so far as reasonable these functions are presented by member agency or department. Funding for the Basic MAREP Service operations is also by agency or department. The operations of the various Specialized Services are treated in a similar manner in that each Service is described by agency participation.

The section on Basic MAREP Service Research is discussed by scientific discipline instead of agency participation, whereas the Specialized Services Research section is prepared by agency or department. A section on international activities describes the U.S. participation in those international organizations that are active in MAREP operations or research. Fiscal data are in separate sections by agency and activity. The facility headings are the same as in the other parts of the report in order to facilitate cross referencing.

Marine Environmental Prediction (MAREP) Services

Basic MAREP Service

The purpose of the Basic MAREP Service is to provide observational data and processed advisories, including warnings and forecasts for the oceans and the Great Lakes. It includes many of the observations, communications, dissemination facilities, and processing centers that make services available to specialized user groups.

Funding for the Basic MAREP Service.—Major program increases in the Basic MAREP Service Operations are reflected by the satellite and forecast augmentation by Commerce (table 1). Within the Department of Commerce, NOAA will continue expansion of its VHF/FM service, providing expanded coverage along the coasts with continuous broadcasts of weather forecasts, warnings, and advisories to the public. Implementation of the Automation of Field Operations and Service (AFOS) program will continue. This will enable forecast and warning preparation

and dissemination to be automated, permitting increased automation of observations.

Operation and expansion of coverage by the Geostationary Operational Environmental Satellite (GOES) system will be continued. GOES I has demonstrated the improved resolution in both time and space of sea surface temperature coverage and observations of real-time cloud cover. The system will also be an integral link in the communication network of the Prototype Environmental Data Buoys being deployed during fiscal year 1976.

The Basic MAREP Service is made up of three interlocking functions as follows: Data Acquisition, Communications, and Data Processing and Information Dissemination.

DATA ACQUISITION

Data Acquisition is the periodic and nonperiodic sensing, measuring, or otherwise determining or describing the state of the ocean and its overlying atmosphere. It includes methods of data collection, recording, and pre-processing, interfaces with communications systems; and deployment and maintenance of observational platforms.

The acquisition of sufficient data to describe temporally the ocean-atmosphere three-dimensional system, considering the various scales, parameters, and the accuracy and representativeness of the data is a major problem. Optimum use must be made of observations from platforms primarily funded for other purposes. Generally, marine observations in most ocean areas are sparse because of the high costs of adding and operating more platforms. Ocean prediction programs require that observational data be collected and disseminated in a real-time mode; climatological models, however, do not have this real-time data requirement.

Table 1.—Funding of the Basic Marine Environmental Prediction Service Operations, by agency

[Thousands of dollars]

Agency	FY 75	FY 76	Difference
Commerce	48,869.5	54,277.9	+ 5,408
Defense	2,334	2,318	— 16
Interior	1,650	1,800	+ 150
Transportation	8,802	9,279	+ 477
Smithsonian	1,362	1,362	-----
Total	63,017	69,036.9	6,019

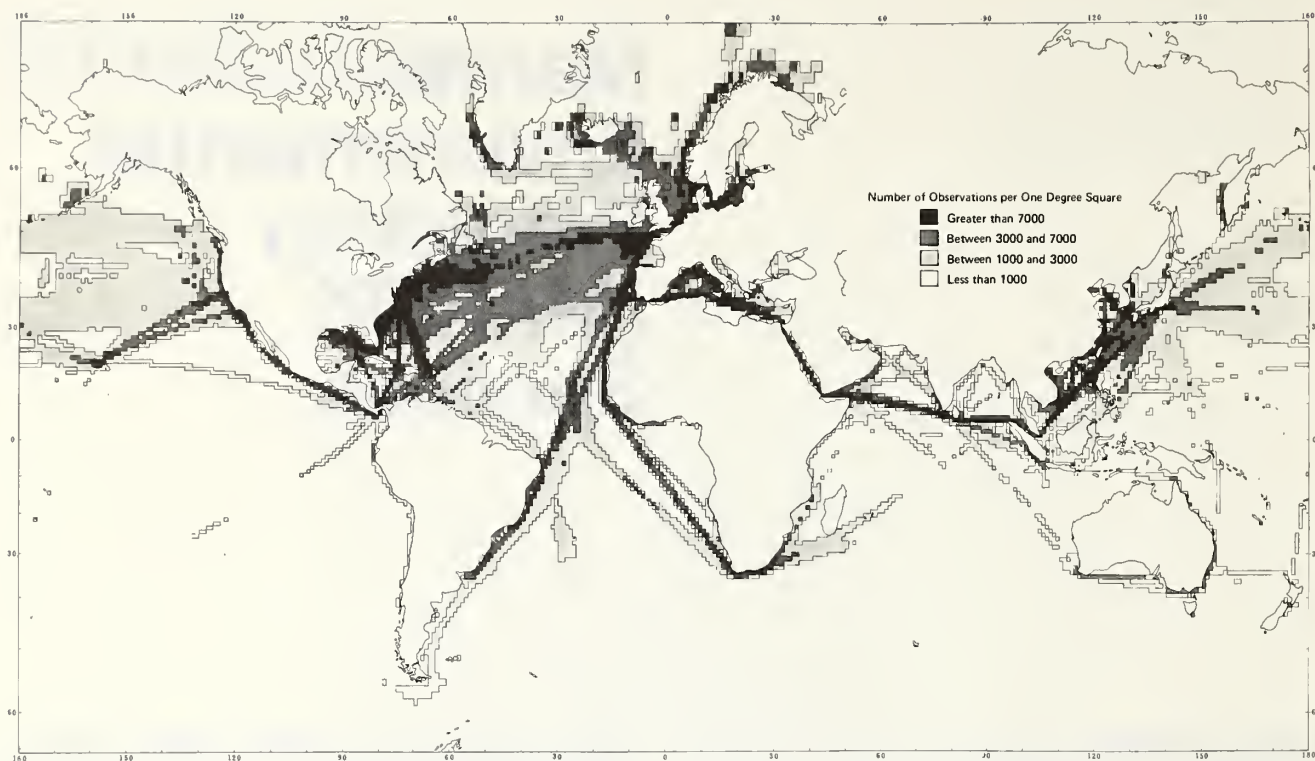


Figure 1.—Historical data distribution of surface marine environmental observations from late 1800s to June 1974. (Data compiled by the Naval Weather Service Detachment, Asheville, N.C.)

Examples of the type of data and the methods by which it is acquired include:

- Surface observations from cooperative ships (fig. 1)
- Surface and subsurface observations and measurements from oceanographic research vessels and environmental data buoys
- Surface observations from Cooperative Coastal Observing Network
- Weather radar observations from coastal stations
- Satellite observations of cloud patterns, sea surface temperature, storm centers, and surface roughness.

Department of Commerce, NOAA

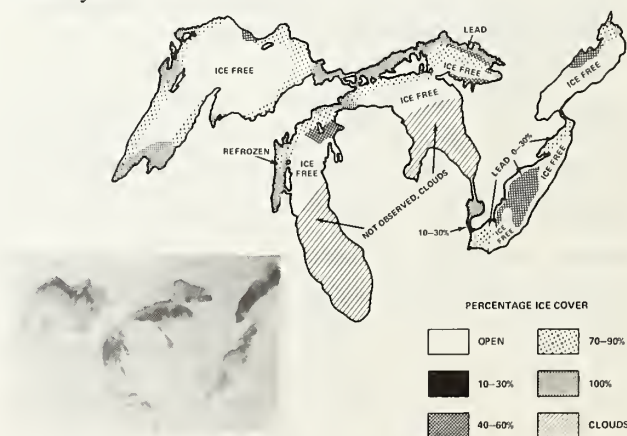
The National Weather Service (NWS) of the National Oceanic and Atmospheric Administration (NOAA) acquires atmospheric and sea surface data which are used specifically for MAREP. The data include radar observations over the ocean from coastal sites and management of the Cooperative Merchant Ship Observational Program. Trained personnel and appropriate equipment are placed aboard Ocean Weather Station (OWS) *HOTEL* to provide upper air, surface, and subsurface observations.

Satellite observations of large-scale synoptic weather patterns over oceanic areas add substantially to the forecaster's information on atmospheric conditions and thus enhance predictions of oceanic storms. Pictures of Great Lakes and sea ice coverage are also useful in preparing information on the character and distribution of ice fields (fig. 2).

Environmental buoys, operated by NOAA's Data Buoy Office, take time-continuous meteorological and ocean temperature measurements and transmit upon interrogation from the Coast Guard Shore Collection Center at Miami, Fla. Environmental buoys are used to support the National East Coast Winter Storms Operations Plan during the winter seasons for improving the accuracy and timeliness of coastal storm warnings. Data are also used during periods of tropical cyclone activity to support the National Hurricane Operations Plan.

The National Ocean Survey (NOS) of NOAA oper-

Figure 2.—Satellite imagery and interpretation of the Great Lakes ice fields provides a navigation aid to the shipping industry.



ates a continuous control network of 135 tide stations along the coasts and within the major embayments of the United States, Puerto Rico, other U.S. territories and possessions, and the U.S. Trust Territory of the Pacific Islands. Temporary stations are occupied on an intermittent basis to increase the effective coverage of the control network, to support hydrographic operations, and to conduct special studies. NOS Lake Survey Center operates a network of four permanent, year-round water level gaging stations on the Great Lakes and their outflow rivers and approximately 70 temporary water level gages which are installed in selected harbors each year on a seasonal basis. NOS measures currents at stations along coastal areas and in estuaries to provide information for tidal current predictions and tends current stations to support estuarine studies.

The National Marine Fisheries Service (NMFS) monitors changes in the populations of important fish stocks and their environment as part of its Marine Resources Monitoring, Assessment, and Prediction (MARMAP) program. This nationally coordinated resource assessment program annually provides forecasts and warnings of changes in fish and shellfish stocks to support fishery allocation and management decisions. The environmental information collected includes observations of oceanographic and meteorological data and mineral and organic constituents of the marine environment.

Department of Transportation

Department of Transportation oceanographic and meteorological data are acquired by the Coast Guard during operation of 17 High Endurance Cutters (HECs) engaged in law enforcement and treaty missions and in the manning of OWS *HOTEL*, special operations such as the GARP Atlantic Tropical Experiment (GATE) project, and



Figure 3.—Infrared Radiation Thermometer (IRT) mounted in a Coast Guard HU-16 aircraft used for Airborne Radiation Thermometry (ART) surveys to depict sea surface temperatures.

at other times when data acquisition did not interfere with the vessels' primary missions. Fiscal year 1974 saw the disestablishment of all ocean stations except OWS *HOTEL* (which is operated from August 1 to April 15 every year) and the simultaneous decommissioning of 13 HECs.

The International Ice Patrol Vessel *EVERGREEN* continues to operate as an oceanographic research vessel carrying out descriptive oceanography, current measurements, and surface meteorology in support of special projects. Icebreakers carried out extensive marine science operations in polar regions during 1975.

Figure 4.—USGS scientist measures water quality and saltwater encroachment in the Florida Everglades and along the Florida east coast.





Figure 5.—Smithsonian Oceanographic Sorting Center staff examine benthic samples collected during a recent cruise.

The Coast Guard prepares monthly surface isotherm charts of the Atlantic and Pacific coasts by the use of Airborne Radiation Thermometry (ART) (fig. 3) and, in conjunction with ART, a marine species observation program. These services provide the marine community with ocean current information for track planning purposes and fish school information for commercial fisheries.

Department of Defense

The Army Corps of Engineers supported a variety of engineering studies in the coastal zone during 1975; these include observations required for stream gaging, sedimentation studies, and information on the hydroclimate network. Other DOD activities are described in a later section on national security.

Department of the Interior

Data acquisition activities of the Geological Survey in marine hydrology and hydraulics are limited to the near coastal zone. Here the Survey operates coastal gaging stations; makes observations of dissolved mineral and organic constituents; obtains similar background data on water quality in estuaries, canals, and adjacent natural channels; operates tide gage stations for special purposes; and monitors the extent and magnitude of saltwater encroachment at certain localities like Florida's east coast (fig. 4). As of 1975 the USGS data collection network comprised 775 stations at which fresh water inflow to the oceans and Great Lakes is computed.

In recent years, efforts have been made to substantially increase the amount of point data collected in coastal waters and to begin studies into the hydrology and hydrodynamics of typical estuaries. This data collection network is largely multipurpose, but also supports the Specialized MAREP Service for Water Quality Assessment.

Water quality data are observed at 370 of the 775 flow gaging stations. Some provide only temperature and sediment concentrations, but most provide regular observations of temperature, specific conductance, and the concentrations of common ions.

Smithsonian Institution

The Smithsonian Oceanographic Sorting Center (SOSC) is a national facility which expedites the acquisition and use of biological collections. In recent years SOSC's capabilities and interests have grown with the national concern for the environment, particularly the increasing need for biological data critical to environmental impact statements. This information can be used as a basis for retrospective and prospective monitoring of environmental changes.

The science of systematics, however, remains at the core of the Sorting Center's services. It provides an identity-oriented base for ecological assessment after making determinations of both the kinds of organisms and their relative abundance temporally and spatially. Today, with increasing environmental stress on biological populations, systematics and its many applications are vital to the preservation and conservation of our natural resources (fig. 5).

NASA

NASA is mapping snow and ice on the surface of the Great Lakes in winter from aircraft using Side Looking Airborne Radar in a cooperative program with the Coast Guard and the National Weather Service. The information is sent to shipping interests in time for them to decide whether to sail and what route to take.

COMMUNICATIONS

The transmitting, with minimum delay, of raw data acquired by various sensors to the processing centers; processed data from center to center; and predictions, warnings, and other information to the user.

The Basic MAREP Service depends heavily for support upon the communication systems of the Basic Meteorological Service just as it does for observational data. The communication media shared by these Basic Services are as follows:

- Teletypewriter network operated by FAA.
- Radar Report and Warning Coordination System (RAWARC), a teletypewriter system operated by NOAA.
- Teletypewriter networks operated by the Coast Guard.
- Teletypewriter and high-speed circuits, both domestic and with overseas terminals, operated by the Departments of Commerce and Defense.
- NOAA Weather Wire Service, a teletypewriter network to distribute forecasts and warnings to the press, radio, and television.
- Facsimile networks operated by the Departments of Commerce, Defense, and Transportation.
- Continuous VHF/FM radio broadcasts operated by NOAA. These broadcasts on 162.55 and 162.40 MHz have a range of about 20–40 miles; 64 facilities at coastal or inland water locations are now in operation.
- Seven NWS marine radio stations in Alaska. Broadcasts are announced on 2,182 kHz, but are heard on 2,382 kHz or 2,512 kHz amplitude modulation, single sideband.
- Marine continuous wave (CW) radio broadcasts operated by the Navy and Coast Guard.
- Radiotelephone, radiotelegraph, and facsimile marine radio broadcasts by the Coast Guard. There are 49 facilities making over 200 broadcasts per day covering essentially all U.S. maritime areas of responsibility.
- U.S. Coast Guard communication and radio stations to collect marine weather observations from merchant vessels.

There is an increasing reliance upon available high-speed civil and military computer-to-computer data relay-and-exchange facilities. These facilities include the Defense global automated environmental data networks. Commerce operates five international circuits to exchange meteorological data between the United States and Canada, U.S.S.R., United Kingdom, Japan, and Brazil. These include a Washington-Toronto high-speed circuit; a Washington-Moscow circuit for exchange of satellite information; and

three other circuits: Washington-Bracknell, England, Washington-Tokyo, and Washington-Brasilia as part of the World Weather Watch program.

Automatic marine telephone-answering services are operated by NOAA throughout the year at 68 coastal locations. These provide the latest forecasts and warnings for marine users in their areas. Similar local information may be obtained on request from most Coast Guard stations or NOAA's National Weather Service through listed telephones.

The Coast Guard cooperates with NOAA by broadcasting marine weather information to shipping and other maritime users. Additionally, warnings of hazardous conditions are transmitted upon receipt and repeated periodically. Texts for these broadcasts are prepared by NWS. Coast Guard communications facilities are also used for International Ice Patrol broadcasts and for reporting oceanographic and meteorological observations.

Communications are required to transmit marine data and information in relatively short time for a number of associated agency programs. The National Oceanographic Data Center (NODC) of NOAA operates a network of teletype terminals with selected scientific institutions. This service includes terminals in Woods Hole, Mass., La Jolla, Calif., Boulder, Colo., and Miami, Fla. In connection with the Pacific Tsunami Warning System, communication support is obtained through a cooperative arrangement for data collection and watch-and-warning services using FAA, NASA, military, and other communication channels.

DATA PROCESSING AND INFORMATION DISSEMINATION

Data processing is the correlating of data collected from the various elements and preparing analyses, assessments, and forecasts for the marine environmental phenomena. Also included are related operations such as data plotting, forecast verification, archiving, statistical analysis, and summarization.

Information dissemination is the delivery of products and environmental services, involving output from data processing to the ultimate users so that they can make operational decisions and conclusions partly on the basis of the information provided.

Real-Time Data Management

There are three major types of data processing centers: primary, area and guidance, and specialized. Primary centers are facilities which prepare general analyses and forecasts on a hemispheric or national basis for use by other centers. Area and guidance centers have analysis, forecasting, and warning responsibilities on an area, regional, or command basis and use the outputs of primary centers, supplemented by their own processing functions to provide detailed product services to users. Specialized centers provide data management or analyses, long-term predictions, or single-purpose services not available from other centers to users or user groups.

Department of Commerce.—NOAA's data processing



Figure 6.—Timely forecasts and warnings of hurricanes help to prevent property damage to residents and industry in low coastal areas.

and information dissemination systems contribute significantly to marine meteorological predictions and warnings. Forecasts are currently available for marine weather, sea, breakers and surf, sea ice, storm surges, and seiches. The hurricane forecasting service also constitutes an essential element of the Basic MAREP Service (fig. 6).

NOAA operates four primary centers which provide products and support to marine meteorology in addition to their larger role in the Basic Meteorological Service. The National Meteorological Center (NMC) in Maryland provides broad-scale analyses and forecasts on a hemispheric basis and graphic products for facsimile transmission to high-seas users. The National Environmental Satellite Service (NESS), also in Maryland, operates the national operational environmental satellite system to provide global cloud-cover mosaics, atmospheric and sea surface temperature data, and interpretive products on a daily basis.

The National Hurricane Center (NHC) at Miami issues warnings of tropical cyclones (hurricanes) in the North Atlantic Ocean (west of longitude 35°W), the Caribbean Sea, and the Gulf of Mexico. Hurricane Centers at San Francisco, Calif., and Honolulu, Hawaii, provide similar services in the eastern and central North Pacific Ocean east of longitude 180° . The hurricanes are tracked by plane, satellite, and radar (fig. 7). The National Severe Storms Forecast Center (NSSFC) at Kansas City, Mo.,

issues warnings of severe local storms (thunderstorms and associated winds, hail, and tornadoes) over coastal waters and the 48 contiguous states.

Area and guidance centers include facilities like the Weather Service Forecast Offices (WSFO) which provide coverage for all 50 states and Puerto Rico including analyses, forecasts, and warnings on a regional basis of the

Figure 7.—Radar profile of a hurricane as it appeared on the range-height scope of the NWS radar. Note the generally clear eye about 35–55 mi from the radar and the vertical buildup of clouds to over 35,000 ft at the near side of the eye.

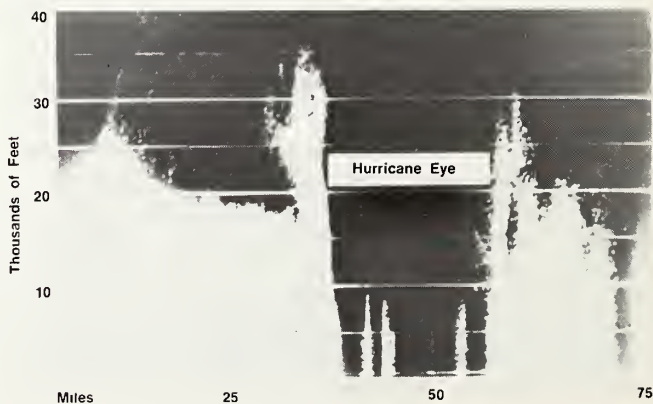




Figure 8.—The 1960 tsunami that struck Hawaii, though resulting in large property damages, caused few deaths due to the timely warnings. Those people that were lost were primarily those that went to the beach to watch the waves (Honolulu Advertiser).

coastal areas and the Great Lakes. Twenty-three of the WSFOs issue forecasts and warnings for coastal waters and the Great Lakes. Offshore and fishing activities in the Pacific and Atlantic are supported partly by the coastal and high-seas products provided for each area.

The Automation of Field Operations and Services (AFOS) program of the NWS has been developed to provide automated techniques and equipment for the field forecast services. On-site minicomputers and TV-type displays provide assistance to the forecaster through data retrieval, forecast composition and monitoring, and data, forecast, and warning dissemination. Each WSFO will be linked to all other WSFOs and related offices. The minicomputer permits the office to act as the collection point for all data acquired within its area of responsibility.

This high-speed data handling system also permits each office to act as a disseminating point for forecasts, warnings, and other information originating from anywhere within NWS. Forecasters use numerical models to predict tropical storm surges. In the case of an extratropical storm surge, statistical techniques are used to give estimates of storm surge heights for certain east coast areas. The Ocean Services Division of NWS issues sea surface temperature means, anomalies, and selected bathythermograph data in its monthly Gulf Stream Summary. Additional information on the location of the Gulf Stream axis and warm and cold eddies and short articles on Gulf Stream research are also included in each issue.

High-seas area marine forecasts, broadcast through Coast Guard radio facilities including facsimile, were be-

gun by NOAA in 1971 from the east coast and in 1973 from the west coast. These forecasts are in addition to those on radiotelegraph and voice broadcasts.

Major Weather Service Forecast Offices in Washington, San Francisco, and Honolulu provide support to meet the minimum analysis and forecasting requirements in the area of U.S. responsibility for shipping forecasts and warnings (which include large designated portions of the North Atlantic and North Pacific) under the Convention on Safety of Life at Sea (SOLAS) and in response to agreements within the World Meteorological Organization (WMO).

The Pacific Tsunami Warning System, operated by NOAA and supported in part by seismic data from the Geological Survey involves coordination of activities at several administrative and governmental levels (fig. 8). The Warning Center is at Honolulu where data are received from a network of 32 seismograph stations and 52 tide stations. Analyses and warnings are formulated, and warnings disseminated to 15 countries and territories and in bordering the Pacific Ocean (fig. 9).

Staffs at the Honolulu Observatory, the International Tsunami Warning Center in the International Tsunami Information Center, and at the Palmer Regional Warning Center in Alaska continuously monitor seismic and tsunami activity; install, maintain, and service the instruments; locate earthquakes; activate the warning system; issue watches, warnings, and cancellations; and provide historical and advisory scientific information.

Department of Transportation.—Besides broadcasting,

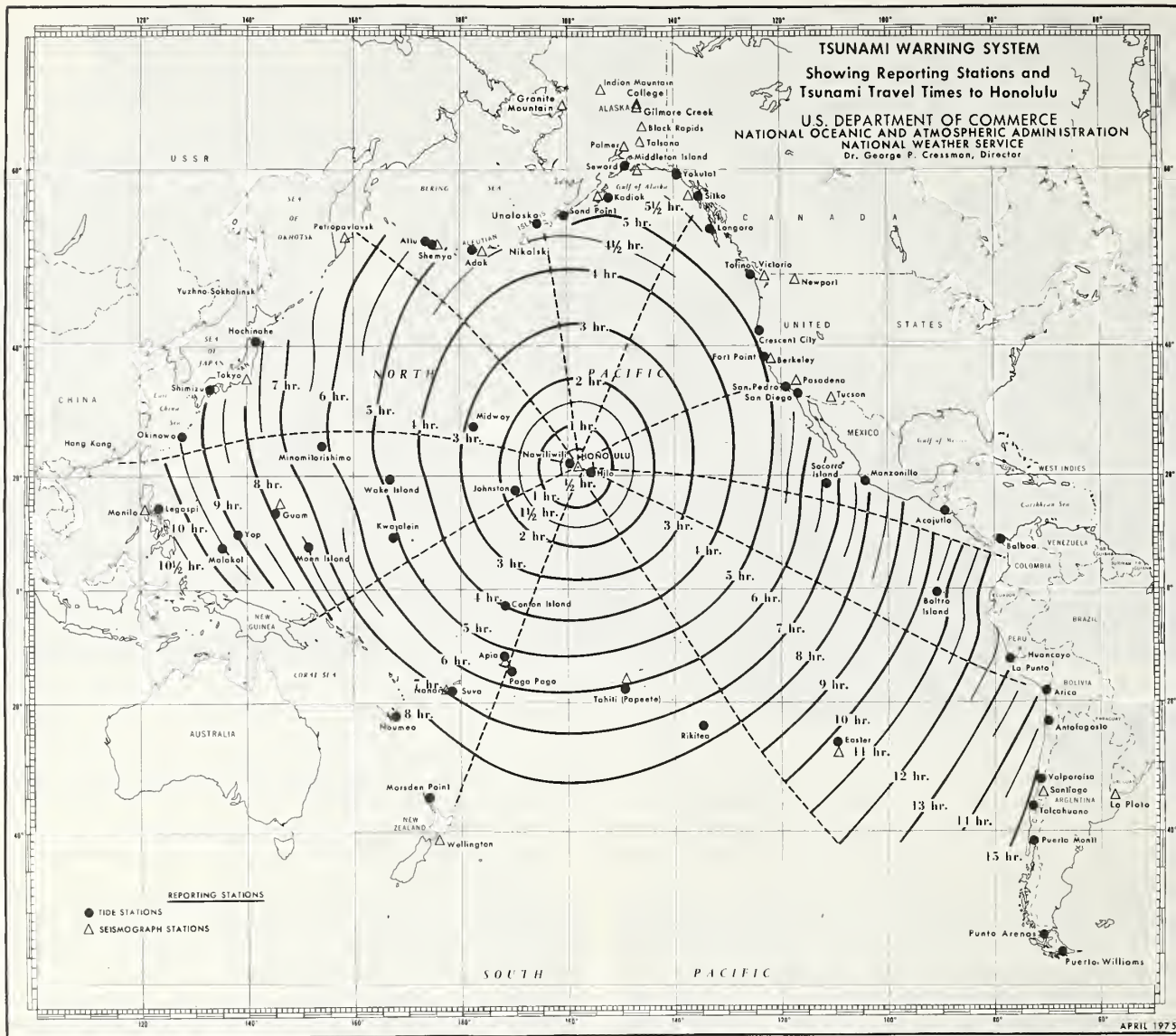


Figure 9.—Tsunami Warning System.

the MAREP services of the Coast Guard include technical support and participation in the Coastal Warning System.

The Coast Guard Oceanographic Unit processes data and provides technical and scientific support for Coast Guard marine programs. The Coast Guard also provides preliminary reduction and processing of environmental data from all of its sources at east and west coast centers to insure continuity of its oceanographic programs.

The Coastal Warning System is a cooperative network of visual (flag and light) displays maintained at prominent locations along the seacoast, the Great Lakes, and inland waterways to advise boating and other marine interests whenever small craft, gale, storm, and hurricane warnings, issued by NWS of NOAA, are in effect. Yacht clubs, marinas, and other private marine activities, State and local governments, the Coast Guard, and NWS participate in this system of 450 display stations. The Department of Transportation (Coast Guard) has 183 lighthouses, lifeboat

stations, lightships, and other facilities participating in the Coastal Warning System. The Department of Commerce (NOAA) operates an additional 128 displays; non-Federal interests operate the remainder on a cooperative basis. In addition, small-craft pennants are displayed by State police patrol craft on Chesapeake Bay, in the New York City area, and on Lake Michigan.

Non-Real Time Data Management

Much of the Basic MAREP Service does not depend upon dissemination of real-time data analyses. Such services include data management and publications of climatological summaries, atlases, tide and tidal current predictions, and long-term studies of effects on the environment of particular geographical regions.

Department of Commerce.—The National Ocean Survey (NOS) of NOAA predicts the tides and the times and heights of high and low waters resulting from astronomical

cal force for 56 locations in the United States and its territories and possessions and for 40 locations in 19 different nations and the Trust Territory of the Pacific Islands under U.S. jurisdiction. Predictions for approximately 6,000 secondary locations are computed through the application of empirical constants. Tide predictions based on harmonic analysis are made by computer and published annually in four volumes. Predictions for 100 reference ports in foreign countries received through a cooperative exchange program are also included in the U.S. Tables.

Tidal currents are predicted for 36 coastal and harbor locations in the United States. These predictions include times of slack waters and the times, speeds, and directions of maximum tidal currents. Empirical constants provide predictions at about 2,000 additional locations. Predictions for 15 foreign stations are received through a cooperative program and published in the U.S. Tables. Charts showing the areal distribution of tidal currents for each hour in the tidal cycle are available for nine major U.S. harbors and estuaries; charts for additional estuaries are under construction.

NOAA's National Marine Fisheries Service processes, stores, analyzes, and disseminates marine fishery data through its Marine Resources Monitoring, Assessment, and Prediction (MARMAP) program. This service provides forecasts and warnings of changes in fish and shellfish

stocks. This information is used in part to assure optimal yields from other stocks. The stock forecasts (fig. 10) support the U.S. in negotiations for management and allocation of stocks under the terms of six international commissions and 10 bilateral agreements. They also support domestic management programs in cooperation with States in three interstate commissions and four State-Federal programs. Data analysis tasks of the MARMAP program combine survey results, catch statistics, biometric data, information on environmental conditions, and food chain dynamics to produce updated stock assessments. These analyses make possible the measurement of fishing and natural mortality rates and of annual changes in abundance caused by environmental changes.

Environmental Data Service provides environmental data, data products, and information in various forms required for the development and conservation of natural resources; public health, safety, and welfare; and the understanding and efficient use of the environment. These marine data are provided by the various national centers within the Environmental Data Service.

- The National Climatic Center (NCC) at Asheville, N.C., processes, analyzes, and disseminates climatological information. Data products include:
 - Summary of synoptic meteorological observations
 - Mariner's Weather Log

Figure 10.—A school of haddock on the George's Bank. Haddock is one of the species that have been heavily overfished and one of the major focal points for the annual MARMAP Resource Surveys.





Figure 11.—NODC's automated inventory is updated through keyboard entry at a remote CRT terminal.

- Marine Climatological Summaries
- Marine World Wide Climatological Guide to Tropical Storms at Sea.

The Satellite Data Service Branch of NCC archives, retrieves, reproduces, and disseminates satellite imagery data by photograph and magnetic tape format. These

data are from environmental satellites past, present, and future.

- The National Oceanographic Data Center (NODC), located in Washington, D.C., is the largest repository of unclassified oceanographic data in the world and the primary source of these data in the United States (fig. 11). The data are made available to government agencies (Federal, State, and local), academic and private research institutions, industry, and the general public by request on a cost reimbursable basis. Four regional liaison offices in key locations of the United States provide the local marine data user with information and technical advice on acquiring and using the Center's files and data product output. A large volume of data is also acquired through international data exchange agreements.
- Environmental Data Index (ENDEX) provides direct computer access and referral service to national and international sources of environmental data and information. NODC products include:
 - Atlases
 - Inventories (including indexes to marine data held by domestic and foreign activities)
 - Special summaries (prepared on request)
 - Archived empirical data.

Figure 12.—A National Guard helicopter rescues victims trapped by the floodwaters of hurricane Agnes.



- NOAA's Center for Experimental Design and Data Analysis (CEDDA) in Washington, D.C., provides services and support in data management and scientific analysis for large-scale environmental field research projects such as GATE (GARP Atlantic Tropical Experiment), BOMEX-II (Barbados Oceanographic/Meteorological Experiment), and IFYGL (International Field Year for the Great Lakes).

Department of Defense.—The U.S. Army Corps of Engineers conducts several projects for processing marine environmental data in connection with its marine engineering studies. In support of basic and applied hydraulic and hydrologic studies are the development of stage-discharge relations in outflow rivers and the determination of the effects on the levels and outflows of the Great Lakes of such factors as: natural and manmade changes in the outflow rivers, diversions into and out of the Great Lakes Basin, and fluctuations between the Lakes. General hydrologic studies involve the analyses of rainfall-runoff relations, snowmelt studies, flood forecasting (fig. 12), analyses of past floods, infiltration indexes, unit hydrographs, and the development of flood hydrographs and other studies related to hydrology. NWS of NOAA prepares meteorological studies required by the Corps for the planning, design, and operation of water-control structures.

The Army Corps of Engineers provides specialized technical services on request to State and local governments. These services consist of information on the use of flood plains of the coastal zone.

Many of the MAREP observations made by the U.S. Navy in support of national security operations are disseminated to civilian MAREP services. Included are:

- Thousands of bathythermograms turned over to NOAA's National Weather Service and National Oceanographic Data Center for public release
- Data reports, summaries, atlases
- Daily releases from the Fleet Numerical Weather Central (FNWC)

Department of Interior.—The U.S. Geological Survey analyzes and processes data collected at estuarine and coastal stations in support of its projects in hydrology and hydraulics. USGS also provides data on stream discharge and water quality which are processed in its own Computer Center Division. The Survey supplies water quality information to the Storage and Retrieval (STORET) System operated in cooperation with the Office of Water Programs of the Environmental Protection Agency (EPA). These data are available to all users. The Office of Water Data Coordination, USGS, coordinates water data collection and dissemination activities within the continental United States, including its estuaries, under Office of Management and Budget (OMB) Circular A-67.

GENERAL AGENCY SUPPORT

General agency support refers to the operational activities, such as training of personnel, maintenance of



Figure 13.—Naval officers receive postgraduate training in oceanography from the Naval Postgraduate School.

equipment and facilities, and internal support, necessary to provide MAREP Services effectively and efficiently.

Training

Training in marine observations, communications, maintenance, and similar technician-level skills is accomplished in schools operated by Federal agencies; professional-level training is obtained at accredited colleges and universities or their equivalent.

The Naval Postgraduate School at Monterey conducts an Environmental Sciences Program to qualify commissioned officers as oceanographers and meteorologists through advanced-degree studies and independent research (fig. 13). A limited number of officers from other military services, the Coast Guard, NOAA, and selected foreign countries attend. Naval officers are also selected for advanced-degrec studies at civilian universities. The postgraduate Master of Science curricula cover 12–24-month periods and include lecture and laboratory courses in air-sea interaction, waves, swell, sea temperature, and acoustical parameters and courses in meteorological forecasting methods. Emphasis is placed upon prediction methods having applications to antisubmarine warfare (ASW).

NAVOCEANO sends selected scientists to universities for advanced training in oceanography, mathematics, computer science, and disciplines which will contribute to projects having an application to MAREP. Naval officers from other nations are trained at NAVOCEANO in those aspects of oceanography that are important to analysis and prediction. Enlisted oceanographers are trained at the Naval Air Technical Training Center, Lakehurst, N.J. Included in their basic training, the junior enlisted ratings are given 2 weeks of basic oceanography and familiarization with oceanographic ASW products. More advanced training is offered midcareer enlisted people attending the AGC7 school. Instruction in this school covers oceano-



Figure 14.—Green seas on deck. Environmental charts from radiofacsimile installation should help masters avoid rough sea conditions (photo: American Export Isbrandtsen Lines).

graphic forecasting and applied geophysics. In addition the Navy trains electronics technicians in a 48-week equipment maintenance course at Lakehurst in the repair and maintenance of specialized meteorological and oceanographic equipment utilized by naval activities.

Coast Guard personnel receive advanced training at Coast Guard and Navy schools to participate in the Basic Meteorological Service observation program and to meet Coast Guard requirements. Basic meteorological training is conducted specifically as a part of the Marine Science Technician Service School curriculum.

The Coast Guard also supports postgraduate training in oceanography for some of its officers at several universities and provides an ocean science major within the curriculum of the U.S. Coast Guard Academy.

Selected personnel from the Department of Commerce (NOAA) receive advanced training in their field of specialization or in complementary areas. NMFS scientists receive training in biology, fishery science, and oceanography in university programs to help improve MARMAP Service related to living marine resources. Forecasters from NWS are also receiving oceanography training in university programs. Such training, in addition to that already received in meteorology, is valuable for producing wave, swell, surf, storm surge, and other marine services. NOAA Corps officers receive their training, which includes oceanographic and meteorological courses, at the U.S. Merchant Marine Academy.

Maintenance

Maintenance activities cover those measures taken to keep equipment in proper operating condition and to repair such equipment when it fails. Included are maintenance personnel, test equipment, and spare parts for meteorological and ocean-sensing equipment. Maintenance for communications systems is also included.



Figure 15.—Strandings as the result of storm surge associated with hurricane Carmen, Gulf of Mexico, 1970.

General

General mission-related activities in support of MAREP operations within a Federal agency include the following types of programs:

- Engineering support for planning, preparing specifications, surveying equipment sites for suitability, and inspecting and calibrating new equipment.
- Scientific studies and consultant services to determine the feasibility of new programs and to increase the effectiveness of current programs.
- Quality control of products to assure the maintenance of standards for accuracy and productivity.
- Employee housing and housekeeping or utility-type equipment at remote-area locations.

Plans for Service Improvement

NOAA with the cooperation of the Coast Guard will deploy six prototype environmental buoys (PEBs) in the northeast Pacific-Gulf of Alaska region. These buoys will provide surface meteorological data that will enhance forecasting in the region.

NOAA's National Weather Service WSFOs are being equipped with high-quality photorecorders for GOES data. At present 25 of the 52 WSFOs receive the photographs for the Satellite Field Service Stations. By 1978 all 52 Offices should be equipped with recorders.

The National Hurricane Center (NHC) is experimenting with a hurricane forecast model, which will go into routine use in 1976. This model will include a reduced grid diameter providing enhanced resolution.

Specialized MAREP Services

Many marine operations are of a nature such that they require specialized marine environmental prediction services. The Basic MAREP Services, with their diversified

applicability, provide the foundation for the Specialized MAREP Services which include Maritime Commerce, Water Quality Assessment, Living Marine Resources, and National Security. Each of these services will be discussed separately. The Specialized Services draw upon the data output of the Basic MAREP Service to produce products needed to serve the operational needs of the particular user groups.

MARITIME COMMERCE

These environmental data and information services and facilities are established or operated to meet the requirements of shipping for safety in navigating the high seas, coastal and inland waters, and harbors. Routinely included are routing services to ships including predicted height of sea waves (fig. 14); the direction and velocity of water currents in the oceans along the coast and in harbor areas; and the water levels in harbors and their approaches. Additional services include warnings of hurricanes and other severe storms, tropical and extratropical storm surge warnings (fig. 15), surface weather analyses and prognoses, and localized marine weather forecasts for the recreational boating population.

The interagency Demonstration Program to extend the Shipping Season on the Great Lakes and St. Lawrence Seaway, initiated during the 1974-75 winter shipping season, will be continued during the 1975-76 season. The Ice Navigation Center operated by the U.S. Coast Guard maintains communications with the Canadian forecast offices and the WSFO in Detroit via the NOAA/NWS marine communications network. Ice reconnaissance flights are conducted by the Coast Guard in conjunction with NASA using Side-Looking Airborne Radar (SLAR).

The Coast Guard is expanding research to meet the projected capability requirements to provide safe navigation and marine environmental protection along the north coast of Alaska.

Major NOAA increases in Specialized Service for Maritime Commerce are reflected by expanded VHF/FM coverage along the coastal areas and, to a less degree, the production of climatic data services.

The Demonstration Program (authorized by the River

and Harbor Act of 1970) will continue through fiscal year 1976 (fig. 16). The Ice Information Working Group plans and coordinates activities concerned with ice cover and weather services in connection with the extension of the winter navigational season. During fiscal year 1976 the Ice Navigation Center will continue to be operated by the U.S. Coast Guard. NOAA's National Weather Service will station an ice forecast specialist at the Center, operate a contract ice forecast program at WSFO Detroit, and maintain a marine communications network around the Great Lakes connecting U.S. and Canadian forecast offices, the Coast Guard Ice Navigation Center, and marine broadcast stations. The Coast Guard and NASA provided ice reconnaissance, utilizing Side-Looking Airborne Radar (SLAR) and ice thickness flights during the Program. Improved prediction for snow ice and ice fog are direct benefits from this program. These prediction techniques are being expanded to the Arctic as well as the Great Lakes.

The need for information concerning the environment has increased at an equal pace with the shipment of oil and natural gas in the Gulf of Alaska. The Department of Commerce provides for sea ice advisories out of WSFO Anchorage for Cook Inlet, the approaches to Anchorage, Alaska, and for the tug and barge operations around Alaska to the North Slope.

A new Maritime Commerce Service product issued by National Weather Service is the biweekly analysis of the location of the inner wall of the Gulf Stream from the tip of Florida to approximately 38°N. These analyses, which are based on satellite- and ship-recorded sea surface temperatures and expendable bathythermograph data, are used by east coast shipping to determine the optimum track to utilize or avoid the Gulf Stream high velocity core (fig. 17).

The Coast Guard manages and operates the International Ice Patrol which alerts traffic in the North Atlantic shipping lanes to the presence of icebergs. Ice reconnaissance and current studies provide the International Ice Patrol with a means to predict iceberg density and movement.

Plans for service improvement.—Projections on the development of the Alaskan North Slope oil resources indicate the eventual necessity for direct shipment of oil by water transport from the Alaskan north coast. Coast Guard efforts are being focused on developing the capability to enhance safe navigation and protect the marine environment. Efforts include:

- Development of structural requirements for Arctic oil tankers and barges
- Determination of the extent of seasonal and all-year navigability of water routes to the north coast of Alaska
- Development of a routing system for navigation of ships through ice-covered waters

The National Ocean Survey (NOS) of NOAA is expanding its efforts to develop an adequate tidal current measuring network in the Alaska area.

Table 2.—Funding of the specialized Marine Environmental Prediction Service for Maritime Commerce, by agency

[Thousands of dollars]

Agency	FY 75	FY 76	Difference
Commerce	59,610	6,007	+46
Defense	50	39	-11
Transportation	2,003	1,824	-179
Total	80,143	7,870	-144



Figure 16.—The Extended Shipping Season on the Great Lakes is made possible by the cooperative efforts of several agencies. Pictured is a USCG icebreaker assisting an ore barge.

WATER QUALITY ASSESSMENT

National concern for improved water quality was the prime motivating force behind the "Federal Water Pollution Control Act Amendments of 1972" (PL 92-500) and the "Marine Protection, Research, and Sanctuaries Act of 1972" (PL 92-532). These two instruments of Federal legislation gave new direction and meaning to programs designed to protect water quality in marine areas. Particular areas of concern are coastal zone waters, estuaries, the Great Lakes, and the oceans.

Implementation of Federal legislation by means of criteria development and regulation promulgation has become a continuing process, supplemented by enforcement activities and research and development. The major responsibility for protection of water quality rests with the

Figure 17.—Infrared imagery of the Gulf Stream permits a delineation of the west wall and inference of the location of the velocity core, allowing shipping to utilize or avoid the Stream.



Figure 18.—Offshore mobile oil rig (photo: EXXON).

U.S. Environmental Protection Agency (EPA). In addition to EPA's regulatory activities, other Federal agencies play a major role in marine water quality assessment. These agencies are the National Oceanic and Atmospheric Administration (Department of Commerce), the Coast Guard (Department of Transportation), the Geological Survey (Department of the Interior), and the Army Corps of Engineers (Department of Defense).

The major increase in the field of water quality assessment continues to be that of the Interior Department as they expand their OCS operations (table 3). Increases are designated to cover the cost of monitoring and supervising of exploration, development, and production activities on the OCS oil and gas leaseholds by the Conservation Division, U.S. Geological Survey. Activities include the maintenance of an alert system to warn of potential or actual oil spills as well as inspecting to assure compliance with regulations. A major portion of the new funds will go to establish new operations offices in potential petroleum-producing regions outside the Gulf of Mexico (fig. 18).

Increases in the Commerce funding are due to ship time allocations for the Marine Ecosystems Analysis (MESA).

The National Oil and Hazardous Substances Pollution Contingency Plan and the Deep Water Ports Act have given the Coast Guard added responsibility in the water quality enforcement field.

Table 3.—Funding of the specialized Marine Environmental Prediction Service for Water Quality Assessment, by agency
[Thousands of dollars]

Agency	FY 75	FY 76	Difference
Commerce	753	1,013	+ 260
Defense	90	90	0
Interior	9,896	14,155	+ 4,259
Transportation	757	798	+ 41
EPA	6,724	6,388	— 336
Total	18,220	22,444	+ 4,224

Generally, programs designed to protect water quality in marine areas can be considered in one of three categories:

- Monitoring and surveillance
- Control and prevention of spills of oil and hazardous materials
- Control of ocean dumping and disposal

Monitoring and Surveillance

In the area of marine environmental quality monitoring, EPA and the National Oceanic and Atmospheric Administration (NOAA) participate jointly in several programs. EPA's Gulf Breeze Laboratory conducts a residual pesticide monitoring program designed to assess long-term toxic effects of pesticides in marine organisms. Programs of a related nature are the subject of investigations at NOAA's National Marine Fisheries Service Laboratories. The programs will provide baseline data and establish overall trends to assist operational programs and enforcement actions.

Under an agreement with EPA and largely funded by EPA, NASA is outfitting an EPA vessel for automated Great Lakes monitoring. This effort also includes data management and display techniques, network and communication strategy, and mathematical transport and dispersal models.

NOAA's monitoring activities also include assessment of tidal currents in oceans and estuaries and determination of physical and chemical characteristics of the Great Lakes waters. These activities are part of the National Ocean Survey Program. NOAA and EPA laboratories are also engaged in projects designed to describe the fate-and-effect relationships for various pollutants. Another joint EPA-NOAA venture—the monitoring of the New York Bight area—is described in detail in connection with ongoing ocean dumping programs.

In connection with the establishment of water quality criteria for marine waters, EPA is also engaged in monitoring to establish a data base for criteria documentation. An area of special concern is shellfish beds, which are particularly sensitive to high concentrations of pollutants. The



Figure 19.—Coast Guard HU-16 equipped with airborne oil surveillance system.

EPA Monitoring and Data Support Division is reviewing ongoing monitoring programs in the estuaries, oceans, and contiguous zones for input to the planned expansion of their National Water Quality Surveillance system called for under Section 104(a)(5) of PL 92-500.

The U.S. Geological Survey (USGS) monitors water quality in streams at the heads of estuaries as a part of the National Stream Quality Accounting Network. Samples taken in estuarine areas are analyzed generally for trace metals, total and fecal coliform bacteria, pH, temperature, and ion concentration. At some sites, turbidity, nutrients, dissolved oxygen, and biochemical oxygen demand (BOD) are also measured.

Selected U.S. Coast Guard vessels and land stations, equipped with salinity-temperature-depth (STD) sensors and sampling devices are used in a variety of in-house and co-operative programs for the analysis of properties of coastal waters. In addition, the Coast Guard conducts tar ball sampling on a regular basis from seagoing cutters for evaluating dispersion of marine pollutants and effective-

ness of oil control measures. Tar ball data is also utilized in the IGOSS Marine Pollution Monitoring pilot program.

More elaborate and exotic techniques, including airborne surveillance and remote-sensing devices, are seeing increased usage as they are developed and improved. The Coast Guard's four-sensor Airborne Oil Surveillance System (fig. 19), successfully developed in fiscal years 1973 through 1975, will be miniaturized for installation in a new medium-range search aircraft. The system, with proven all-weather, day and night detection of oil capabilities, will continue to be improved with identification and qualification capabilities added on. Continued research into the system's usefulness in detecting non-oil pollutants, ice, icebergs, search and rescue targets, territorial waters' violators, and for obtaining surface water temperature data will be conducted.

International monitoring for petroleum pollutants commenced in 1975 through the IGOSS Marine Pollution Monitoring Pilot Project. Oil slicks and other surface pollutants are observed visually, and petroleum residues (tar



Figure 20.—The draft of the supertankers and the regulations at many U.S. ports make the need for deepwater ports apparent. The impact of discharges from supertankers makes a careful environmental assessment, forecast, and monitoring scheme an important MAREP consideration for Specialized Water Quality Assessment Services.

balls) collected from surface tows are recorded. Preliminary mapping of tar balls concentrations in the Atlantic Ocean has been done from data collected by the National Marine Fisheries Service (NMFS) in the Marine Resources Monitoring, Assessment, and Prediction (MARMAP) Program and by the Coast Guard in oceanographic surveys. Water samples taken for the Pilot Project from 1-metre depths will be analyzed by laboratories for petroleum hydrocarbon content. Assessment of the accumulation of tar on beaches is also part of the Pilot Project.

Control and Prevention of Spills of Oil and Hazardous Materials

The primary agencies involved in efforts to control and prevent discharges of oil and other hazardous materials in coastal and inland waters are the Coast Guard and EPA. A major effort in the control of discharged oil is directed toward the forecast of surface wind, waves, and currents, compounded in the coastal zone by tidal currents. The Coast Guard has developed numerical models using these wind and wave data for coastal trajectory analyses to aid in the control and cleanup of spills and discharges.

The Deepwater Port Act of 1974 has given the Coast Guard lead responsibility for all deepwater ports that will

be constructed outside the 3-mile U.S. territorial sea. The deepwater ports now envisioned will be single-point moorings to service supertankers (fig. 20). Though the Coast Guard has lead responsibility, NOAA has been assigned the task of reviewing applicant environmental impact statements and proposed monitoring plans. In addition, a determination will be made of the probability that another State will be impacted by spilled or discharged oil to a greater degree than the State with the port.

This will draw upon the extensive data banks of the Environmental Data Service.

The Coast Guard, as designated by the National Oil and Hazardous Substances Pollution Contingency Plan, is charged with the amelioration of discharges of oil and hazardous materials in the U.S. coastal waters, including ports and harbors. EPA has similar responsibilities for the inland regions. As provided by the Contingency Plan, a National Response Center (NRC) is maintained under the cognizance of the Coast Guard in Washington, D.C. The NRC is a continuously manned operations center designed to receive reports of discharges and to coordinate Federal response efforts, should a national level of involvement be necessary. During a pollution emergency, the National Strike Force is often called to the scene (fig. 21) to provide specialized experts or pollution emergency equip-



Figure 21.—USCG personnel, National Strike Force, pumping oil from the METULA in the St. of Magellan.

ment as appropriate. During such incidents, surface observational data are often necessary to aid the designated On-Scene Coordinator in assessing the effectiveness of containment and removal efforts and to forecast the probable impact of the incident on the marine environment.

Other Federal agencies also play an important part in spill prevention and cleanup. Under the Outer Continental Shelf Lands Act, the Geological Survey's Conservation Division is involved in monitoring and supervision of exploration, development, and production activities of oil and gas leaseholds on the outer shelf. Important background data on living marine resources, structure design, oceanographic characteristics, and tidal influences are provided by NOAA. This information is used to augment the efforts of other agencies in combating emergency situations created by spills.

By Memorandum of Understanding between the Department of Transportation and the Department of Interior, the Coast Guard has assumed responsibility for response activities within the high seas area covered by the Outer Continental Shelf Lands Act.

Control of Ocean Dumping and Disposal

Under the Marine Protection, Research, and Sanctuaries Act of 1972 as amended. EPA has developed proce-

dures for the evaluation and issuance of ocean dumping permits. Ocean dumping criteria establishing maximum allowable concentrations of materials have been published and are subject to revision as new data become available.

Several bioassay techniques have been developed for use in the ocean dumping permit program to evaluate the relative toxicity of the material to be ocean dumped. The research strategy to develop the needed data base for the ocean dumping program is being formulated in a cooperative effort by NOAA, the Corps of Engineers, the Coast Guard, the Navy, the National Science Foundation, and EPA.

Overall coordination of ocean dumping activities is by an interagency committee chaired by EPA and including NOAA, the Coast Guard, the Council on Environmental Quality (CEQ), and the Corps of Engineers. Under the Ocean Disposal Permit Program, all ocean dumping activities are being closely controlled by EPA (fig. 22). EPA has designated a total of 110 ocean disposal sites on an interim basis. Suspected violations of permit conditions and other instances of illegal dumping are reported to EPA by the Coast Guard, and appropriate enforcement actions are taken as necessary.

One aspect of the ocean dumping program involves the determination of an alternate dump site in the New



Figure 22.—Ocean dumping of urban refuse is closely regulated by EPA.

York Bight. EPA is conducting a baseline survey of the area with additional input from NOAA's Marine Ecosystem Analysis (MESA) Project.

Other sources of potential pollution problems are ocean outfalls and dredging operations. Ocean outfalls (such as municipal sewage outlets) are regulated by EPA under NPDES permits (section 402 of the FWPCA). Research to determine the fate and effect of waste effluents in the marine environment is currently being carried out by EPA. Permits for the disposal of dredged material are regulated by the Corps of Engineers (COE), subject to review by EPA. Criteria for this disposal are included in the Ocean Dumping Regulations and Criteria. The Corps is engaged in a 5-year research program which will provide baseline data necessary for the evaluation of dredged material disposal sites. EPA is developing dump site monitoring methodology for dredge spoil, industrial waste, and sewage sludge dump sites.

The Environmental Assessment Division of the National Marine Fisheries Service participates in environmental prediction by assessing the impacts of environmental alterations on the habitat of living marine resources. Operating under the Fish and Wildlife Coordination Act, the National Environmental Policy Act of 1969, the Federal Water Pollution Control Act Amendments of 1972,

and approximately 15 other acts, the Division analyzes, comments on, and makes recommendations on a wide variety of water development, waste discharge, and other projects which could adversely affect marine recreational and commercial fisheries. These efforts to reduce damage to the resources are pursued by reviewing and reporting on dredge and fill proposals, by EPA waste discharge and ocean dumping permits, COE permits for construction in navigable waters, environmental impact statements, AEC and Federal Power Commission license applications, and other proposed water development projects of public and private agencies operating under Federal permit or license. All these activities relate to water quality if that term is broadly defined to include all kinds of habitat alterations, whether physical, chemical, or biological.

Plans for Service Improvement

None identified.

LIVING MARINE RESOURCES

Federal responsibility for providing a MAREP service for living marine resources to those who utilize them or are responsible for their management and conservation rests with the National Marine Fisheries Service of NOAA. The Department of Interior, through the Fish and Wildlife



Figure 23.—Tournament fishing for bluefin tuna off the south New England coast. Competition between sport and commercial fishermen for this declining resource has led to conflict.

Service, is responsible for MAREP service for living resources in the Great Lakes.

The major increase in the MAREP Specialized Service for Living Marine Resources (table 4) is provided by the Department of Commerce. The National Marine Fisheries Service expects to increase its MARMAP activities in FY 1976. MARMAP survey coverage of important resource stocks will be expanded in the North Pacific, East Bering Sea, and the Northwest Atlantic where overfishing problems are especially acute and assessment data are not otherwise available. For the fisheries in the North Pacific, we are dependent upon foreign catch data which are difficult to obtain and unreliable.

Cooperative bottom fish surveys will be conducted with other countries, universities, and State laboratories using Federal, private, and State research vessels. The surveys will cover many different species and their environments and will measure changes in the abundance and distribution of all resource species of importance to the U.S. They will provide estimates of change in fish and shellfish abundance without the sampling bias that exists in catch data from commercial and recreational fishing operations.

Improvements will be made in automatic data process-

Table 4.—Funding of the specialized Marine Environmental Prediction Service for Living Marine Resources, by agency

[Thousands of dollars]

Agency	FY 75	FY 76	Difference
Commerce	8,812	10,604	+ 1,792
Transportation	726	813	+ 87
Total	9,538	11,417	+ 1,879



Figure 24.—Central Pacific Ocean live-bait yellowfin tuna fishing. The migration and distribution of tunas are closely correlated with the migrations and distribution of oceanographic parameters.

ing (ADP) systems for producing more timely fishery forecasts and warnings needed for management decisions.

Fish and Shellfish

Stocks off the U.S. coast are an enormous renewable resource; the annual harvest by foreign and U.S. fishermen currently averages 11 billion pounds, valued at approximately \$6 billion retail. The potential annual catch from the U.S. coastal resource is estimated between 20 and 40 billion pounds. Competitive harvesting by foreign and domestic fishermen has led to serious overfishing of at least 10 major commercial stocks. The economic consequences of overfishing, exemplified by the overexploitation of the California sardine and the Atlantic haddock, have resulted in an accumulated loss to fishermen in excess of half a billion dollars as of 1974. Another problem is allocation of resources between commercial and recreational fishermen (fig. 23). NOAA's Marine Resources Monitoring, Assessment, and Prediction (MARMAP) program is designed to collect and analyze information necessary to solve these problems. MARMAP is a nationally coordinated resource assessment system which annually provides forecasts and warnings of changes in coastal fish and shellfish stocks. The principal elements of the MARMAP system include resource surveys, analysis of fishery catch data, fishery oceanography (fig. 24), and fishery engineering. Fishery



Figure 25.—Sorting and identification of plankton from MARMAP surveys provides data on abundance and distribution of fish eggs and larvae and of planktonic forage organisms.

engineering and fishery oceanography are described in the section on research to improve MAREP service for living marine resources.

The MARMAP program obtains resource information from several multipurpose surveys. One type of survey assesses eggs and larvae (fig. 25) when they are concentrated near the surface and can be sampled with a standard net. A second type of survey focuses on the abundance and distribution of fish and shellfish species which live at or near the bottom in their harvestable stages (e.g., cod, flounder, scallop, lobster, crab, and shrimp). A third type of survey assesses pelagic fish species. MARMAP assessment surveys are also conducted as part of energy-related environmental studies in oil and gas leasing areas. Data from distant waters are obtained through use of cooperative vessels of the merchant fleet (ships of opportunity). Such ships, with government-installed data collection equipment, are ideal platforms for making ocean-wide observations.

MARMAP fishery oceanographic activities are directed toward:

- Describing and analyzing marine organic production systems and oceanographic conditions
- Defining the influence of environmental factors on the distribution and abundance of living marine resources

These objectives are accomplished by analyzing physical, chemical, and biological oceanographic data collected during MARMAP surveys and during oceanographic research by other sources (e.g., ships of opportunity, Navy, Coast Guard, States, and universities). The fishery oceanography

program has developed an annual seasonal upwelling index for the west coast which will be useful in understanding the biological productivity of this region.

The Coast Guard also provides services to improve the utilization of living marine resources. Periodic aerial flights over the Atlantic and Pacific Oceans record sea temperature using remote sensing infrared thermometers. This information is distributed monthly to various institutions and users in the form of charts of surface isotherms. These charts, now in their 12th year of publication, are of direct use to fishermen in selecting the best fishing areas and to scientists studying the coastal waters. These flights also record data on the distribution of large surface swimming animals (sharks, turtles, whales, schools of fish) and the presence of foreign fleets. Through the auspices of its Oceanographic Unit, the Coast Guard conducts spring and autumn oceanographic surveys of the northwest Atlantic fisheries area as part of its coastal monitoring and research effort. Surveys include Nansen and STD cast and neuston net tows. Sample analyses include examination of biota, inorganic nutrients, and tar balls.

Plans for Service Improvement

None identified.

NATIONAL SECURITY

Activities of the Department of Defense require MAREP Services of a specialized military nature. The information needs, however, are often the same as those of Commerce, Transportation, or Interior. For example, programs in antisubmarine warfare (ASW), mine warfare, specialized military salvage, and amphibious warfare require the same generic data (e.g., sea state, water column thermal structure, distribution of planktonic organisms) as their civilian scientific counterparts in the National Weather Service, National Marine Fisheries Service, or Coast Guard. The collection systems to provide these data are generally the same or at least compatible, and since fleet operations require information and predictions of a more extensive nature than the basic MAREP services, they can provide the Basic and Specialized MAREP services with a large volume of otherwise unobtainable data.

The nature of MAREP services designed for military applications is such that they require a totally independent system. This is the only specialized MAREP service with all the basic system elements.

- Data acquisition platforms, internally supported
- Data collection and communication systems
- Data processing and product dissemination systems

The Fleet Numerical Weather Central (FNWC) is a full-service, worldwide real-time data processing and dissemination center that provides continually updated forecasts tailored to the military's needs. Many of the products are also distributed to civilian users.

The Department of Defense decreased its operational budget for Specialized MAREP Services for National Security from \$13,853,000 in FY 1975 to \$13,460,000 in FY 1976.

MAREP Research and Development

Considerable research and development is being performed for the purpose of improving the basic and specialized MAREP services. This work includes data acquisition, communication, processing, and dissemination which have immediate application from studies of the basic oceanic processes and which support the services on a longer range basis. This chapter will define the principal MAREP research and development programs in terms of the current academic disciplines of marine meteorology, physical oceanography, chemical oceanography, biological oceanography, polar studies, and ocean technology, although most oceanic research and development is not entirely in one such area. A separate section on interdisciplinary activities covers those which cannot be easily categorized or which include multiple areas. Research activities concerned with the improvement of the Specialized Services are discussed in terms of their funding increases.

Increases in MAREP research are designated as increases in the Basic MAREP research or in those research activities that are designed to improve one of the Specialized Services.

Basic MAREP Research

Increases in Basic MAREP Research funding can be examined to analyze trends and changes in Federal priorities. The major funding increase for a MAREP research item is through increased focus on the OCS by the Department of Interior. Increases were also made by NSF and to a less degree by NASA and Transportation. Both Commerce and Defense remained at essentially level funding (table 5).

Reprogramming by Interior of its coastal and marine hydrology projects has assigned new resources to these areas to meet the needs of both the "upstream water users," who are experiencing increased restraints on their upstream activities, and the estuarine and coastal water users who are experiencing increased impacts on their downstream activities. Further offshore, research by the Bureau of Land Management consists of numerous contract studies for baseline evaluations of the environment of potential OCS petroleum leasing areas as well as contract studies for environmental monitoring after commercial operations begin.

A major decrease in NOAA research and funding is the reduction in the environmental buoy program as the EEBs (Engineering Environmental Buoys) become PEBs (Prototype Environmental Buoys).

National Science Foundation increases are for support of an offshore resources program in the Arctic including (1) the development of a rapid remote sensing technique for describing and classifying different sea ice types, (2) an experiment to develop the ability to predict drift and deformation of near-shore ice, (3) an investigation to develop detailed knowledge of the distribution and characteristics of offshore permafrost, and (4) a program to investigate

Table 5.—Basic Marine Environmental Prediction Research, by agency

[Thousands of dollars]

Agency	FY 75	FY 76	Difference
Commerce	40,398	40,388	— 10
Defense	6,434	6,519	+ 85
Interior	37,485	60,263	+ 22,778
Transportation	2,468	2,620	+ 152
ERDA	11,487	12,000	+ 513
NASA	530	780	+ 250
NSF	21,200	23,800	+ 2,600
Smithsonian	1,757	1,757	0
Total	121,759	148,127	+ 26,368

all aspects of bottom scouring. Additional increases are for initiation of the U.S.-U.S.S.R. Central North Atlantic Experiment (POLYMODE) which will attempt to determine the relationship between the average mean ocean circulation and the medium-scale eddies.

Increased research efforts by NASA involve cooperative agreements with EPA for development of automated Great Lakes monitoring systems and with NOAA for remotely tracking drifting buoys along the North Atlantic coastal zone.

MARINE METEOROLOGY

Much of the research to improve the marine meteorological forecasting is the same research needed for other areas of meteorology. Therefore, such programs as NOAA's and the Navy's large atmospheric dynamic modeling studies have not been included as MAREP items.

Research in sea-air interaction is conducted by NOAA and the Navy to understand and quantify the energy exchange processes between the ocean and atmosphere involving transfer of heat, moisture, and momentum. These energy exchange processes contribute significantly to the generation of the world's weather patterns and to the destructive forces of hurricanes and other severe ocean and weather occurrences.

Automated surface wind forecasts have been developed by NOAA for the Great Lakes, and resulting wind predictions are used as input to a Great Lakes wave forecast model. An automated technique for forecasting surface winds at eight light station locations off the east coast has also been developed. This provides the basis for forecasting wave conditions for recreational boaters, fishermen, and commercial shipping.

The Geostationary Operational Environmental Satellite (GOES) is being used to provide cloud (fig. 26) and wind fields in near-real-time over land and the ocean areas surrounding North and South America. Although data

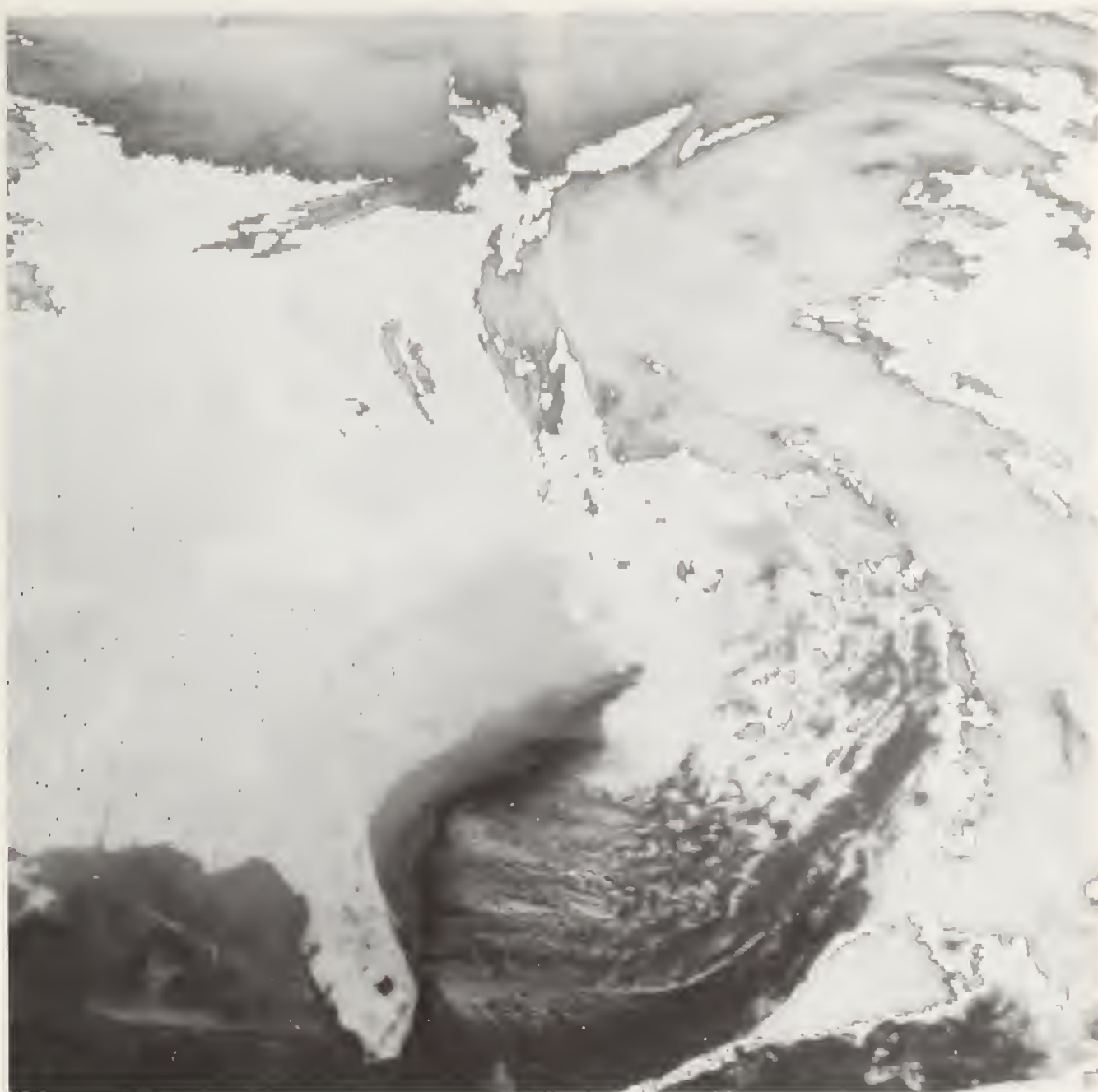


Figure 26.—GOES imagery will permit real-time interpretation of cloud cover.

interpretation is only in the R&D phase, results are encouraging for ultimate operational use.

The NORPAX program, under the joint auspices of NSF's IDOE and the Office of Naval Research, is a major study of long-period, large-scale ocean-atmosphere coupling in the North Pacific Ocean (fig. 27). NSF supports other research on air-sea interaction including: a laboratory study (using a wave tank of microphysical transfer processes) of large-scale pressure variations in the Ekman layer and field and laboratory studies of turbulent transfer at the sea surface including comparison with the French tank facility at Marseilles.

Application of the Global Atmospheric Research Program (GARP) to the open oceans in the next few years will principally entail the analysis of the oceanographic and air-sea interaction studies which took place in the GARP Atlantic Tropical Experiment (GATE) in 1974 (fig. 28) and the planning for the First GARP Global Experiment (FGGE), in which observations of atmospheric and oceanic parameters over major world oceans will play an important role. GARP is under the guidance of NOAA with major NSF support for participating scientists from the universities and from the National Center for Atmosphere Research.

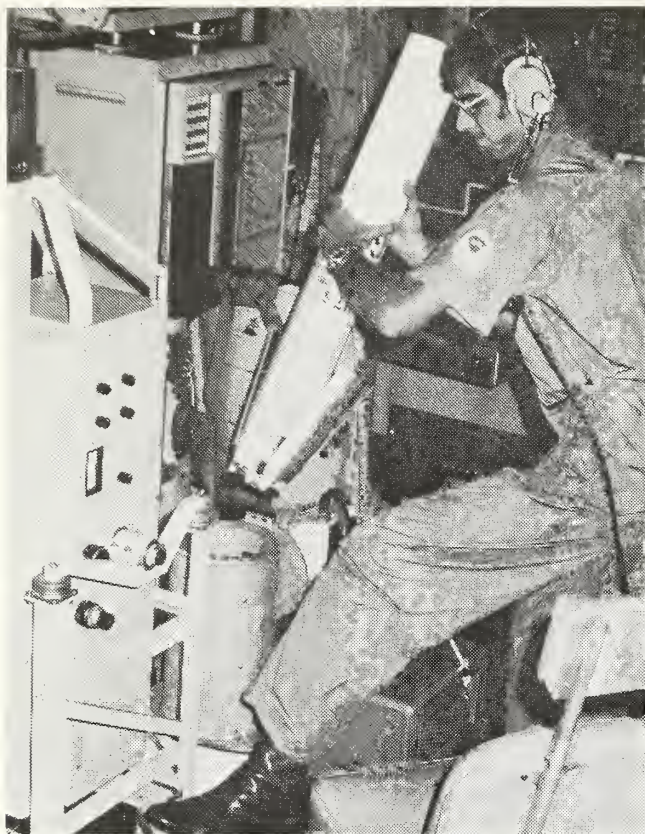


Figure 27.—An expendable bathythermograph (XBT) is prepared for aerial launch during NORPAX.

PHYSICAL OCEANOGRAPHY

Physical oceanography includes the description and theoretical explanation of the physical processes and aspects in and of the ocean itself. Physical oceanographic research thus includes studies of waves, currents, temperature, density, and other phenomena which affect ships and shipping; transport of pollutants, plankton, and sediment; acoustical propagation which impacts antisubmarine warfare (ASW) operations; and the weather and climate. For the purposes of MAREP the upper ocean and boundary effects are of primary importance.

The physical oceanographic research projects that are relevant to MAREP include theoretical and experimental studies of ocean and lake circulation, structure, and density distributions; wind waves; tsunamis; storm surges; and ice. They are aimed at improving: the monitoring and prediction of severe conditions so that their effects can be minimized, the management of our resources, and the efficiency with which we live and work in the marine environment.

Support from the Division of Environmental Sciences of NSF is principally for individual unsolicited projects carried out by scientists from the major U.S. oceanographic institutions. Their physical oceanography program supports research on the physical processes and descriptions of the ocean, coastal areas, and estuaries; geophysical fluid dynamics; and air-sea interactions. About 40 to 50 awards



Figure 28.—The GARP Atlantic Tropical Experiment (GATE) array included vessels and planes from 70 nations.

are made annually for open ocean studies of which about 50% are concerned with MAREP objectives.

Some EPA research is directed toward the application of mathematical modeling techniques to predict the fate of pollutants in the marine environment and assess their effects on marine ecosystems. A model has been developed to predict the time-spatial distribution of sewage sludge as it is being dumped from a moving barge. Work is underway to evaluate this model in the field.

Circulation studies at NOAA include: (1) Theoretical oceanwide model studies with and without atmospheric interactions, (2) Gulf Stream experiments and models, (3) Gulf of Alaska circulation in support of the Bureau of Land Management (BLM) Outer Continental Shelf program, and (4) circulation in Puget Sound, Great Lakes, and the New York Bight. Currents are mapped by remote, including satellite, techniques as well as classical techniques.

Methods are being derived for global mapping of sea surface temperature, and detailed (1 km) thermal gradient data are being developed from the Very High Resolution Infrared Radiometer (VHRR) on the NOAA 2 (fig. 29) and NOAA 3 satellites. Wind speed, upwelling, seasonal surface water changes, and other phenomena are also observed by this VHRR technique.

The International Southern Ocean Study (ISOS) program funded by NSF is concerned with the dynamics and



Figure 29.—NOAA II Satellite VHRR picture of ocean circulation features in the eastern Gulf of Mexico and southern United States seaboard.

structure of the Antarctic Circumpolar Current, a feature of major importance to deep water exchanges between the Atlantic, Pacific, and Indian Oceans. The first phase of this experiment is in the Drake Passage. The overall objective of ISOS is better predicting of global weather and climate.

The Mid-Ocean Dynamics Experiment, MODE and POLYMODE, also supported by NSF and the Office of Naval Research, are major theoretical and experimental efforts to understand medium-scale ocean eddy circulation.

MODE was a 4-month field experiment carried out in 1973 by U.S. and U.K. scientists to describe these eddies by velocity and pressure measurements. The analysis of these studies should be completed in fiscal year 1975 and will be used in the design of POLYMODE, an attempt to assess the interaction between the eddy fields and ocean circulation. POLYMODE, a joint U.S.-U.S.S.R. study in the central North Atlantic, is scheduled for the period October 1976 to October 1978.

Large-scale ocean density anomalies, which have a

substantial effect on long-range acoustical propagation, are a major area of study by and under the auspices of the Navy. The anomalies, evident over thousands of square kilometres, are known to develop within a couple of weeks and to persist for many months.

Although the MARMAP Program is fishery oriented, certain aspects of fishery oceanography apply to MAREP. For example, an annual seasonal ocean upwelling index has been developed for the U.S. west coast, and the monthly Fishing Information Bulletin provides information on the thermal properties of the eastern Pacific Ocean. Research has been performed on oceanic fronts and cold- and warm-core eddies that break away from the Gulf Stream. The horizontal and vertical extent of these features is being investigated using ships and aircraft. Similarly, propagation loss characteristics of these anomalous water masses are being studied to determine their impact on detection systems. Long-term observations will establish migratory patterns, their degradation with time, and eventual merging with the existing environment. An experimental chart of thermal anomalies in the western North Atlantic is prepared and disseminated twice weekly.

To support these programs, Navy operates three 2,500-ton AGS class ships (*BENT*, *KANE*, and *WILKES*) with occasional AGOR assistance. In addition, two RP-3 aircraft, the *SEASCAN* and *BIRDSEYE*, have been fitted for remote sampling of the ocean environment. *SEASCAN* has an airborne radiation thermometer to measure sea surface temperature, a helium laser to measure waves, expendable telemetering bathythermographs to obtain thermal profiles, and meteorological sensors. *BIRDSEYE* is used primarily for arctic studies and has a laser to profile ice ridges, an infrared scanner for thermal mapping, and a camera for aerial photography. *BIRDSEYE* and *SEASCAN* have 12–14 reconnaissance missions per year and provide data for dynamic modeling and long-range prediction-oriented research. Programs are also funded to develop oceanographic prediction techniques, means for sampling the environment, and applications of ocean forecasts to fleet operations. Research is underway to develop three-dimensional models describing the distribution of temperature and salinity over a grid on the basis of random observations.

A significant NAVOCEANO effort has been devoted toward the improvement of the Water Mass Data File and other data banks and atlases. Designed for use with on-board computer prediction systems, the Water Mass Data File and associated subroutines allow the merger of shallow temperature observation from expendable bathythermographs with historical data taken by other means. Acoustic predictions prepared by this method are much more accurate.

Another area of Navy research is that of underwater visibility which can be restricted by large clouds of suspended material. The increased use of sea floor naval systems and deep diving submarines and submersibles requires a thorough understanding of the nature of deep ocean currents and the degree of underwater visibility and light

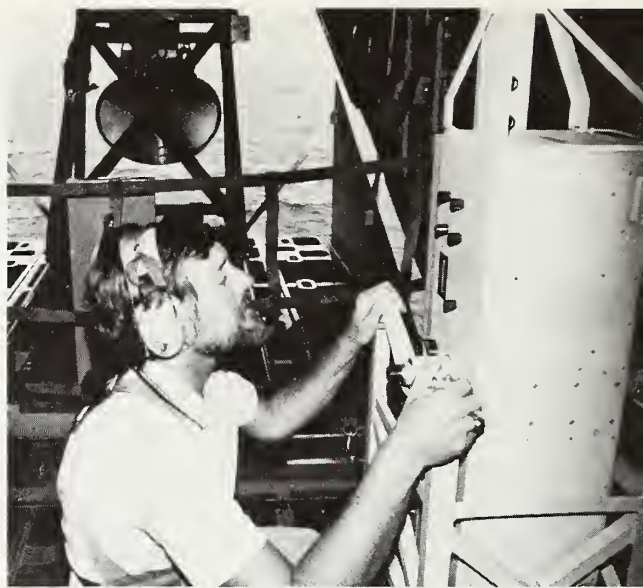


Figure 30.—NOAA airborne laser profileometer for measuring wave heights, used during WISEX (Winter Storm Experiment).

scattering by suspended particles in the water column.

U.S. Coast Guard programs related to understanding the structure and motion of the ocean are directed toward support of the International Ice Patrol and Search and Rescue (SAR) missions. These efforts include studies on water mass exchange and on currents affecting the presence and distribution of icebergs and sea ice in Baffin Bay and through the Grand Banks region. Additional Coast Guard research is directed at responses of boat hulls, rafts, and life saving devices to wind, waves, and currents.

The Navy has programs to improve knowledge of coastal energy sources and response mechanisms of the shore, the sediment, and coastal water motion systems. Of special interest are deltaic and estuarine processes, including interface and mixing of salt and fresh water, tidal behavior, current generation, changes in bottom conditions, and wave propagation and modification. Acquisition and prediction of navigational information are especially important.

The Coast Guard, through its Office of Research and Development, conducts experiments to measure advection and diffusion of floating and suspended pollutants in U.S. coastal waters. Processes studied include Ekman circulation, Langmuir circulation, and thermohaline instability. In addition, water movement information will be provided for several major harbors in support of harbor pollution contingency plans. The leeway and diffusion of various types of oil under varying wind and sea conditions will be studied to improve the Coast Guard's prediction of movement and fate of oil spill at sea.

Wind-wave research at NOAA includes basic observational studies relating to wave growth carried out primarily by remote techniques (fig. 30), wave forecasting methods development, and the forecasting of Great Lakes waves by numerical methods.



Figure 31.—Optimum Track Ship Routing (OTSR) is a major focus for Navy fleet operations, since heavy seas can impair the Navy's efficiency.

The Navy research in this area is significant and includes consideration of the turbulent wind field, the mechanisms of wind-wave generation and growth, and shallow water wave propagation and modification to improve wave forecasts. Wave spectral forecasts are of special interest in hull design studies and ship routing services (fig. 31). Solution to the problem of wave forecasting on an oceanwide basis is well underway through use of large computer facilities. A spectral wave model for the Mediterranean Sea, the North Pacific, and the North Atlantic is being run twice daily on an evaluation basis. A spectral wave model for the South China Sea is being converted for Navy use. A computer program has recently been formulated for wave refraction analysis over the Continental Shelf to the shoreline.

The Army Corps of Engineers has a continuing program to provide environmental data to develop design criteria for structures, alleviate problems of beach erosion, and maintain navigable channels. The work includes interactions between natural phenomena and engineering works to improve design criteria to minimize the impact of the

works on the environment and ecological systems.

Tsunamis are very long ocean waves generated by seismic events. Their runoff over coastlines has caused great damage and loss of life. Tsunami research is carried out primarily by NOAA in support of its Tsunami Warning System in the Pacific. It includes the numerical, linear, and nonlinear hydrodynamics of tsunamis combined with a modest experimental observational program. The major research goals are the ability to make quantitative warnings and the production of tsunami hazard statistics for the coastlines of the Pacific Ocean basin. Seismic research carried out by other agencies (not included in MAREP) is used in these tsunami studies.

Storm surges (fig. 32) are changes in the coastal water level caused by atmospheric events—principally winds but also pressure. Research on these phenomena is carried out by NOAA and DOD. NOAA's previous research on surges generated by hurricanes and other tropical storms has included the development of numerical models applicable to uncomplicated coastlines and storm improvements. The new thrusts are the consideration of coastline curvature



Figure 32.—Hurricane storm surge is the principal mechanism by which low coastal structures are destroyed. Surge associated with a hurricane floods Old Lyme, Conn., on the Long Island Sound north shore.

and bridging from the open coast to bays and other semi-enclosed bodies of water. The extratropical surges in lakes and along coastlines are also being researched. Statistical forecast techniques have been developed for these which are based on the correlation of numerical weather forecasting models. The method is being expanded to include many more locations.

CHEMICAL OCEANOGRAPHY

Chemical oceanographic research included in MAREP covers the distribution and changes in the chemical constituents of the seawater itself and the effects of chemical additives. Corrosion, a chemical interaction, is in general not included primarily because it is in other, non-MAREP areas.

The U.S. Navy carries out research in chemical oceanography to determine the chemical constituents of seawater, to identify means by which they react, and to characterize processes they undergo in the marine environment. This program is directed specifically to problems of direct naval relevance, such as acoustic propagation, and the behavior of materials immersed in the sea and has broad application to other marine-oriented problems such as pollution control and the selection and monitoring of oceanic disposal sites. For example, naval research on the organic chemistry of seawater has developed sufficient insight into characterizing organic molecules present in the ocean through natural biological process and oil injections that it is possible to identify the source of a pollutant incident.

The EPA marine research program includes studies on the fate and effects of trace metals from sewage, dredge spoil, and industrial wastes. Fate and effects studies are also being carried out on oil and persistent organics.

The recently organized Marine Chemistry Program in the Division of Environmental Sciences, NSF, supports selected proposals dealing with the chemical properties and processes of seawater, naturally occurring and manmade compounds in oceanic waters, and the chemical aspects of ocean-atmosphere interactions. It is expected that about one-third of the 40-50 grants awarded in this program will deal with open ocean chemistry related to MAREP objectives.

The Environmental Quality Program of IDOE supports research on the physical-chemical processes that transport, mix, and alter pollutants in the oceans. The research is aimed at further understanding of the levels of compounds and elements in the open ocean which indicate the rate of movements in the water column. North-south transects of the Atlantic and Pacific Oceans in the Geochemical Ocean Sections Study (GEOSECS) collections of large quantities of deep ocean water have yielded precise measurements which are being analyzed at shore-based laboratories for various trace elements and radionuclides.

The Bureau of Land Management, Department of the Interior, conducts studies for baseline environmental evaluations for potential Outer Continental Shelf (OCS) petroleum leasing areas as well as for environmental monitoring

after commercial operations begin. In addition, it makes specific fundamental studies of petroleum toxicity and heavy metals in the Gulf of Mexico and oil-spill matrix studies. Major increases in fiscal year 1976 will be used to fund environmental assessment projects of relatively virgin areas such as the Bering and Beaufort Seas.

BIOLOGICAL OCEANOGRAPHY

The academic discipline of biological oceanography includes the study of all plants and animals living in the ocean. However, MAREP biological oceanographic research is restricted to the part of the field that affects marine operations or is used to measure environmental quality. Thus, purely fisheries studies are excluded.

The primary objective of the MAREP part of the Office of Naval Research (ONR) Oceanic Biology program is to enhance the Navy's capability to predict, evade, or control those biological systems alien to military interests. Most of the research is by academic and nonprofit institutions throughout the United States. The remainder is performed in Navy laboratories. Main emphasis in the ONR biological oceanography program is in bioacoustics and concerns both active and passive sources of sound. Active sources such as marine mammals emit underwater sounds that contribute to the noisy acoustic background of the sea, whereas passive sources such as plankton scatter or reflect sound. These animals interfere with sonar performance by giving false target or false depth information.

Additional oceanic biology efforts are in the prediction of bioluminescence and the behavior of poisonous marine animals and the study of animals that attack or attach themselves to manmade structures and materials in the sea.

The NSF biological oceanography program supports studies with the objective of a better understanding of the types of oceanic organisms and their distribution, behavior, and nutrition as well as their interactions with the marine environment. About one-fifth of the work supported in the open oceans is related to MAREP objectives. Also studied in the program are the rates and mechanism of transfer of metals and other toxics and thermal stress. Further studies in fiscal year 1976 will be devoted to ecological and physiological adaptation to environmental and man-induced stresses.

In the IDOE office of NSF, coastal projects of the environmental quality program include the study of the effect of chemical pollutants on marine life in order to understand how low levels of pollutants, acting over various lengths of time, can harm. A major program in this study is the Controlled Ecosystem Pollution Experiment (CEPEX) in which scientists are investigating an entire marine ecosystem that is enclosed in huge plastic bags in the natural environment.

Interior's Fish and Wildlife Service maintains a research program concerning coastal anadromous fish and for biological monitoring of marine and coastal species of fish and wildlife. In addition, studies are made to evaluate the effects of various Federal construction activities on the



Figure 33.—Measurements made in polar regions, similar in nature to those of lower latitudes, are often more difficult to secure.

ecologic balance of fish and waterfowl.

EPA's marine research program is currently engaged in the development of culturing, rearing, and holding techniques capable of producing quality-controlled marine organisms for experimental use. Studies on the fate and effects of oil, heavy metals, and persistent organics on marine biota are underway.

Operating as part of the Smithsonian Institution Office of Oceanography and Limnology, the Smithsonian Oceanographic Sorting Center (SOSC) provides a service for processing collections of marine specimens to expedite their rapid analysis. This function includes the sorting, cataloging, and distributing of marine plankton, benthos, and fish and geological collections.

POLAR STUDIES

Polar studies encompass the same meteorological, physical, chemical, and biological disciplines that apply elsewhere. However, since the application of these disciplines and the methods of study are generally different in polar regions, such research is most efficiently described as an entity (fig. 33).

Navy polar research is concentrated in the Arctic and supports naval operations there. It includes studies of such unique characteristics of the polar seas as the perennial ice pack and its contiguous areas, seasonal ice, and ionosphere disturbances exemplified by the Aurora Borealis.

The Naval Arctic Research Laboratory (NARL) is a Navy-owned contractor-operated research facility located about 4 miles north of Barrow, Alaska.

From NARL the Navy operates several field stations, including research stations on ice islands. Research at these stations encompasses measurement programs in gravity, magnetics, underwater acoustics, seismology, micrometeorology, physical and chemical oceanography, sediment cor-



Figure 34.—Navy scientist-divers prepare to descend under the Arctic Ice.

ing and heat flow, ice physics, and ice drift (fig. 34). These programs have been supplemented by airborne studies of the distribution and dynamics of pack ice.

Work is continuing on an integrated system, demonstrated during 1973, to measure motions of sea ice in the central Arctic Ocean. Knowledge of ice drift is important for routing of surface and subsurface vehicles. Basic measurements of the position of ice floes were acquired by use of the Navy Navigation Satellite System and a specially designed acoustic bottom reference tracking system. Simulations and analysis taken from ice floe stations suggest that the system will be able to resolve the full spectrum of ice motions during the term of the upcoming Arctic Ice Dynamics Joint Experiment (AIDJEX).

Increasing operational requirements in the Arctic for sea ice reconnaissance prompted the Navy to institute an ice surveillance program to collect statistical data concerning the distribution of various ice features and conditions. Project BIRDSEYE utilizes airborne visual instrumentation to provide intelligence on large-scale ice behavior. Two of these sensors in use are infrared scanners and laser altimeters. Statistical analyses show that spectral "signatures" can be correlated with other ice properties, e.g., age and thickness.

Recent experiments with side-looking radar systems provided direct-image maps of ice terrain with good surface feature resolution and have given encouraging results for further development of these remote sensors.

A study of Arctic sea ice organisms has confirmed the appearance of a visible brown layer on the underside of sea ice which appears in mid-April, being related to the increasing light levels of spring. Understanding this cycle is a key to predicting the sound scattering and sonic targets that result from organisms feeding on algae.

Analysis of recent oceanographic data taken from



Figure 35.—AIDJEX ice buoy.

pack ice stations has confirmed the presence of a western boundary current in the Arctic Ocean. Such a current will affect our understanding of the ice drift and the motion of water masses which affect the sound environment in the Arctic Ocean. The intensified flow off Point Barrow is considered analogous to the western currents of temperate oceans (Gulf Stream and Kuroshio). Field data accumulated during the field investigation of the Arctic Ice Dynamics Joint Experiment (AIDJEX) will be used to elucidate the flow as well as the physical and chemical characteristics of this current.

The AIDJEX program will take place between March 1975 and March 1976 in the central region of the Beaufort Sea in the Arctic Ocean. The goal is to provide improved Arctic weather prediction and ice condition forecasting. Many variables both above and below the ice-covered surface will be measured at manned and unmanned stations to determine the driving forces and ice deformation in the area occupied by the station network (fig. 35). Agencies

involved in AIDJEX are NSF, ONR, NOAA, DOI, and MARAD of the United States and the Department of Energy, Mines, and Resources of Canada.

Projections on the level of development of the Alaskan north slope oil resources indicate the eventual necessity for direct shipment of oil by sea from the Alaskan north coast. Coast Guard research to support this capability will include:

- Development of structural requirements for Arctic oil tankers and barges
- Determination of extent of seasonal and year-round navigability of the water routes to the north coast of Alaska
- Development of a routing system for navigating ships through ice-covered waters.

OCEAN TECHNOLOGY

Improvements in MAREP services depend heavily on development of improved instrumentation, quality assurance, and system efficiency. Research and development in such areas as communication, computers, and platforms are also important.

NASA is carrying out a wide variety of research and development programs generally related to the use of remote sensing techniques. Many of these techniques, although first investigated from aircraft or helicopters, are applicable to satellites. Past efforts toward current measurements (and pollution tracing) and the study of sea ice and other phenomena have been resolved using multispectral imagery from the ERTS 1 satellite. The newer efforts are, in part, directed toward eventual experiments with GOES C, Nimbus G, and SEASAT (1978).

There are a large number of individual efforts carried out at several NASA Centers. They can be summarized by the following categories:

1. Investigation of the capability of optical instruments to sense chlorophyll, sediment, temperature, pollutants, circulation, waves, and ice cover.
2. Investigation of the capability of microwave instruments to sense temperature, salinity, waves, sea surface winds, and ice thickness.
3. Statistical interpretation of remotely sensed data.
4. Mathematical modeling of ocean and Continental Shelf circulation, wave diffraction, and wave-driven currents.
5. Measurement system analysis and data analysis techniques for such satellites as GOES C and SEASAT.
6. Development of satellite instruments.

The mathematical modeling generally is directed toward developing the capability of gaining insight into subsurface phenomena from remotely sensed surface information.

NOAA works closely with NASA in developing this remote sensing capability. Applications include assessment of fisheries environment, physical coastal processes, sea ice, ocean color, and ocean dynamics. Close liaison and cooperation with the various National Aeronautics and



Figure 36.—An array of environmental buoys off each U.S. coast will provide input for weather forecasting and storm warning activities.

Space Administration (NASA) centers and the use of their facilities are maintained, including an experiments schedule using NASA aircraft for investigations by government, university, and industrial scientists.

ERTS imagery has been shown to be useful in ocean dumping studies in the New York Bight region. Aircraft and in situ data are being used to interpret ERTS imagery and to establish the quantitative capability of remote sensors to measure water masses, circulation dynamics, the effects of pollutants, and the baseline monitoring requirements associated with offshore oil leasing and facilities development.

NASA and EPA are carrying out in the Lake Erie area a program to evaluate the use of several remote sensing instruments from aircraft and to simulate the effects of lake circulation by mathematical modeling. It is hoped the models will lend insight into the three-dimensional phenomena in the lake from effects observed on the surface.

The Office of Naval Research addresses its ocean

technology program to two distinct goals:

- Direct technological support of the scientific research undertaken by the Ocean Science and Technology Division of ONR
- Support of new areas of technology which hold promise for both future Navy programs and direct naval application

This ONR program supports improvements in oceanographic instrumentation at the major research institutions and includes support in physical, chemical, biological, and geological oceanography. In addition, sensor and system work is supported at smaller institutions and at commercial sites.

This program also supports innovative marine technology in direct support of fleet problems; for example, a means for permitting amphibious landing craft to operate alongside, or within, assault ships at higher sea states than heretofore possible.

A discrete portion of the program coordinated with the NOAA Data Buoy Office (NDBO) is concerned with advances in buoy technology, both in components and in overall systems. This area is very broad, owing to the great variety of purposes for which surface and subsurface sensor buoys are employed, and the diversity of users and user agencies requires continual coordination.

NDBO is the primary national center for environmental buoy development. Environmental data buoys are planned to support weather forecasting and storm warning activities, oceanographic research, and water quality analyses (fig. 36).

NDBO activity consists of four basic programs:

- Buoy systems development, test, and evaluation
- Deep ocean moored operational buoy procurement and implantation
- Deep ocean moored operational buoy operation and maintenance
- Specialized buoy systems for scientific users

The need for improved instrumentation and data quality assurance has been expressed during the past 15 years in numerous documents and studies. The National Oceanographic Instrumentation Center (NOIC) focuses on the improvement of oceanographic instrument quality and reliability and on acquisition of qualified oceanographic data through appropriate calibration (fig. 37). At present only 10% of the standards required for existing marine data collecting instrumentation are available. The development, review, and updating of required standards are a large part of NOIC's marine instrumentation program. Special facilities needed to calibrate our Nation's marine data gathering instruments are located near most of the major centers of oceanographic activity, i.e., San Diego, Seattle, and Bay St. Louis. The regional centers' services are offered to the commercial, academic, Federal, and State oceanographic community on a reimbursable basis. There are growing needs for international standardization of both instruments and procedures, and NOIC has established liaison with Canada, France, Japan, Federal Republic of Germany,

U.S.S.R., and with international organizations such as the Intergovernmental Oceanographic Commission. NOIC is also involved in an interlaboratory calibration (INCAL) program in which various laboratories calibrate instruments to determine their capability of obtaining comparable data.

INTERDISCIPLINARY ACTIVITIES

The NOAA Marine Ecosystems Analysis (MESA) program includes studies of marine ecology and changes in it that result from human activities and natural forces. Research is undertaken in response to critical issues identified by responsible organizations, including the Council of Environmental Quality, EPA, DOI, the Corps of Engineers, the Coast Guard, and State governments.

In fiscal year 1973 the New York Bight (fig. 38) was selected as the first experimental area for intensive investigation because of the magnitude and urgency of its problems. The large volume of waste being discharged has measurably polluted the marine environment in that region. Offshore development of almost every kind has been proposed, often without fully understanding the environmental economic tradeoffs involved. The purpose of the New York Bight project is to develop marine environmental information and a capability to predict the effects of critical man-induced changes. The following critical issues are being addressed:

- The effects of existing and projected pollution loads that reach the Bight through various pathways, such as river and coastal input and air pollution
- The effects of present and projected ocean dumping of wastes at both existing and alternative sites
- Environmental effects governing the location, construction, and operation of offshore structures such as nuclear power plants and deep water terminals
- Nearshore ocean processes such as currents, wave patterns, and sediment movement relative to coastal zone management and coastal engineering

Field work is scheduled for completion in fiscal year 1980. A series of interim reports and findings are to be issued throughout the lifetime of the project to provide timely information for management decisions.

Manned underwater support is provided to NOAA marine research and investigations. Underwater investigations use research submersibles to ascertain the physical, chemical, and ecological behavior of dumped wastes in near-coastal waters.

In fiscal year 1974 an effort was started in the Pacific Northwest toward cooperative, interdisciplinary research with the Canadians, other Federal and State agencies, and universities in response to environmental degradation resulting from the expected increase in oil tanker traffic and the discharge of treated sewage effluent into Puget Sound. The information gained in this preliminary effort will contribute significantly to a future MESA regional project.

The NOAA Sea Grant program supports Sea Grant colleges and education and research in fields relating to the development of marine resources and marine environ-

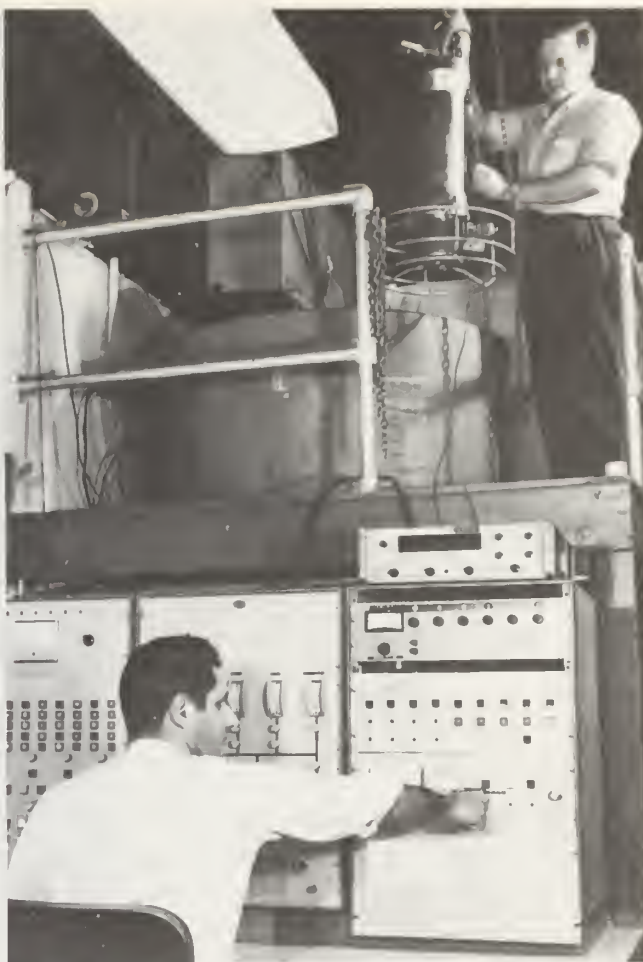


Figure 37.—Periodic calibration of Salinity-Temperature-Depth (STD) sensors insures their continued accuracy and reliability.

mental prediction. MAREP-related Sea Grant projects involve research in the Great Lakes and the coastal zones and estuarine regions of the United States, in the Gulf of Mexico, and in Alaskan and Hawaiian waters.

The marine research program sponsored by the Atomic Energy Commission (AEC) has been focused on determining the environmental factors that influence the movement of radionuclides through the marine environment, their pathways, and the rate of return of radioactivity to man through marine food chains and basic marine ecological processes. This information is needed to address the existing and potential environmental problems resulting from coastal and offshore siting of nuclear power stations and from inadvertent and deliberate use of the oceans as the end point of many waste disposal systems.

The recent broadening of these objectives under the Energy Research Development Administration (ERDA) now supports multidisciplinary studies of nuclear as well as fossil fuel-powered electrical generation plants and their siting which includes the environmental effects of siting and subsequent power plant operation. The research encompasses studies of trace element cycling, modeling of water



Figure 38.—The New York Bight was selected for the first MESA study area because of the intensive urban impact.

circulation, biological productivity, and the effects of waste heat on these marine ecosystems. Insight into physical and biological dynamics is essential for predicting the response of marine ecosystems to the great variety of man-induced stresses.

The study areas of concern are along the coastal margins of the northeast, southeast, Gulf, and southwest continental shelves of the United States. These will be the areas most impacted by the development of coastal and offshore power reactors as well as by other important social, political, and economic considerations in this zone. These research functions are being carried out in each of these areas by offsite contractors in conjunction with the personnel from the ERDA National Laboratories.

As a result of an in-depth review of research projects involving coastal and marine hydrology, the Water Resources Division, U.S. Geological Survey, doubled its previous figures assigned to this activity. The \$4.5 million spent in fiscal year 1975 was almost entirely matched by State and local governments owing to increasing impacts on their coastal zones and by upstream water users who are realizing restraints based on the estuarine and coastal impacts of their activities.

In the research activities of the Geological Division, USGS, studies of the movement of sediments and pollutants in estuaries and bays are included, as are studies of minable sand and gravel on the sea floor, studies of the effect on the sea floor of ice movement as it relates to

offshore mineral development, and studies of sea floor faults as geologic hazards to offshore and onshore developments.

The Great Lakes Environmental Research Laboratory (GLERL) of NOAA was established in April 1974 to investigate the Great Lakes ecology as a system. A main task for the next few years will be the analysis of the data collected from Lake Ontario in 1972-73 during the International Field Year for the Great Lakes (IFYGL). A long-range goal of GLERL is the development of comprehensive models of lake circulation and ecology. Special emphasis will be placed on defining the physical, chemical, and biological processes in the near-shore zone.

High resolution (100 m) imagery from the Earth Resources Technology Satellite (ERTS 1 now called LANDSAT) is used for ice identification over the Great Lakes and polar areas. Turbid waters are clearly seen in ERTS imagery and are used for current tracing and water mass identification.

EPA's research and development programs relating to marine environmental prediction fall into four general areas:

- Studies to determine the effects of various pollutants on marine ecosystems
- Development of standardized methods and monitoring techniques for assessing the effects of various wastes on marine ecosystems
- Design of simulations and mathematical models to aid in predicting the environmental impact of wastes on marine ecosystems
- Research to investigate and technology to control and limit the adverse effects of oil and hazardous materials on the marine environment

Under the auspices of the IDOE Living Resources Program, the first major interdisciplinary study in the Coastal Upwelling Ecosystems Analysis (CUEA) program, JOINT-I, was off northwest Africa from February through May 1974. Ships, equipment, and personnel from 11 countries took part in this 4-month experiment off Cape Blanc. Data were collected by three U.S. ships and one aircraft, two French ships, and ships from Spain, Mauritania, East Germany, and Poland. The extensive data from JOINT-I is now being analyzed and will be compared to that generated by earlier upwelling experiments off the Oregon and California coasts. Preliminary results suggest that precise description of water movement outside an upwelling region is essential for a proper description of the total upwelling circulation and that this outer motion may be strongly affected by the shape of the Continental Shelf and slope. These findings will provide the basis for planning JOINT-II, set for 1976 and 1977 in the distinctive upwelling region off Peru. The main goal of the upwelling research is to understand this phenomenon so that prediction models can provide the scientific basis for improved management and use of marine resources.

In the regional environmental management program of the Research Applied to National Needs (RANN) in

Table 6.—Research funding for the improvement of the specialized Marine Environmental Prediction Service for Maritime Commerce, by agency

[Thousands of dollars]

Agency	FY 75	FY 76	Difference
Commerce	444	444	0
Transportation	322	339	+ 17
ERDA	800	1,100	+300
Total	1,566	1,883	+317

NSF, several ongoing environmental management research projects, such as the Chesapeake Bay area, will be completed and tested. An examination will also be made of the environmental effects of dredging and other coastal zone engineering practices.

Many agencies are continuing research toward extending water transportation on the Great Lakes and western rivers through the winter season. This research had added importance because of the necessity to maintain transport for coal and oil to offset shortages of these sources of energy.

Individual projects include the development of improved ice monitoring and forecasting techniques and studies of ice characteristics as they affect safety, ease, speed, and economy of water transportation.

Specialized MAREP Service Research

Inasmuch as the Basic MAREP Service is, by definition, applicable to cross utilization by the Specialized Services, so too are the research programs. As such, research in support of the Specialized Services is often hard to distinguish from that identified under Basic Service research. Research programs identified here with the Specialized Services are those that support improved service operations. The following breakout of programs represents changes in funding base from fiscal year 1975.

In some instances the programs have been outlined in the previous section on Specialized MAREP Services under "Plans for Improvement."

MARITIME COMMERCE (Table 6)

Engineering efforts are being initiated within Commerce between NOAA and MARAD to develop a small automated meteorological monitoring unit for use on co-operative merchant ships. This unit, named SEAS for Ship-board Environmental Data Acquisition System, is expected to be in prototype by the end of fiscal year 1977.

Coast Guard research is being directed toward preparation of water transport of oil from the Alaskan north coast. Research to enhance safety to navigation and for marine environmental protection includes development of structural requirements for oil transport vessels, deter-

Table 7.—Research funding for the improvement of the specialized Marine Environmental Prediction Service for Water Quality Assessment, by agency

[Thousands of dollars]

Agency	FY 75	FY 76	Difference
Commerce	5,332	7,732	+2,400
Defense	1,610	1,610	0
Interior	0	2,000	+2,000
Transportation	175	216	+ 41
EPA	4,833	5,075	+ 241
NASA	325	650	+ 325
Total	12,275	17,283	+5,007

mination of the length of the navigation season, and development of an optimum track navigation system for ice-covered waters.

WATER QUALITY ASSESSMENT (Table 7)

Increases in water quality assessment research were realized by Commerce for the inner Continental Shelf, mainly on ocean dumping, and by Interior for the outer Continental Shelf, primarily related to oil and gas exploration and production.

Commerce research increases will be necessary to fulfill the basic MESA New York Bight objectives. These are: (1) Determine the fate and effects of pollutants entering the Bight ecosystem, with particular emphasis on ocean dumping; and (2) identify and describe the important subsystems, processes, and driving forces operating in the Bight as a whole and define their interrelations and rates of change. Additional funding will be used to acquire basic data on the environment at selected representative deep ocean manganese nodule mining sites before commercial mining begins.

The Conservation Division of the U.S. Geological Survey will initiate a study of safety devices used in OCS oil exploration, development, and production in an attempt to develop better, more reliable devices.

NASA is planning, with NOAA, a comprehensive program in connection with MESA. Objectives are to investigate the usefulness of remote sensing techniques in monitoring ocean dumping, providing baseline data, and examining the best integration of remote and ground measurements to meet data users' requirements.

LIVING MARINE RESOURCES (Table 8)

Commerce increases for research on living marine resources will be used for contracts to develop sampling systems related to NMFS surveys by the Marine Resource Monitoring, Assessment, and Prediction (MARMAP) program. Included in these sampling systems are contracts to:

- Improve trawl design to reduce by-catch wastage.

Table 8.—Research funding for the improvement of the specialized Marine Environmental Prediction Service for Living Marine Resources, by agency

[Thousands of dollars]

Agency	FY 75	FY 76	Difference
Commerce	6,703	784	+1,138
Interior	6,419	7,000	+ 581
Total	13,122	14,841	+1,719

- Develop hydroacoustic sampling methods for assessing pelagic fish resources.
- Develop optical sampling methods for benthic and pelagic resources. Emphasis will be placed on electric trawls for sampling bottom and midwater fishery stocks. Optical sampling systems will include an improved Remote Underwater Fish Assessment System (RUFAS 2), aerial photographic assessment systems, and a low-light-level television assessment system.

Increases will also be used for expanded studies of organic production systems and of the relations between environmental factors and the distribution and abundance of living marine resources.

The Fish and Wildlife Service of the Interior Department maintains and is expanding a program of research concerning Great Lakes fisheries, coastal anadromous fish, and biological monitoring of marine and coastal species of fish and wildlife. In addition, the effects of various Federal construction activities on the ecological balance of fish and wildlife are being evaluated.

NATIONAL SECURITY (Table 9)

The Navy, as a participant in the Arctic Ice Dynamics Joint Experiment (AIDJEX), will use its Navigation Satellite System to measure ice movement during the term of the experiment. The Office of Naval Research (ONR) supports research toward the improvement of instrumentation and through its ocean technology program addresses itself to two goals: Direct technological support of the research of the Ocean Science Division of ONR, and support of new areas of technology development that will benefit Naval operations.

Table 9.—Research funding for the improvement of the specialized Marine Environmental Prediction Service for National Security, by agency

[Thousands of dollars]

Agency	FY 75	FY 76	Difference
Defense	7,285	7,750	+465
ERDA	625	700	+ 75
Total	7,910	8,450	+540

International Activities

The United Nations and its specialized agencies have continued to expand their activities in marine science on a worldwide basis with participation by the United States in several areas. Through multinational cooperation, various U.S. national programs benefit from expanded oceanic monitoring, enhanced studies of oceanic processes and marine pollution, and technology exchange. Technical details of U.S. participation in these activities are developed through coordination among interested agencies, and positions on issues arising within the international bodies are cleared by the State Department with reference to foreign policy considerations.

Integrated Global Ocean Station System (IGOSS)

The Integrated Global Ocean Station System (IGOSS), a service-oriented program of the Intergovernmental Oceanographic Commission (IOC) sponsored jointly with the World Meteorological Organization (WMO), is a partial international counterpart of MAREP Services of the United States and thus of particular interest because of its broad-scale ocean monitoring potential and its oceanic forecast and advisory services aspects. The IGOSS program includes cooperative activities for unrestricted exchange of ocean observational data, oceanographic products and information, and forecast and advisory services. The lead agency for coordinating technical aspects of the IGOSS Program is NOAA, Department of Commerce.

The BATHY Pilot Project, the first operational IGOSS activity, involves the testing and evaluation of bathythermograph data acquisition and reporting with collection and relay via telecommunications. It started in January 1972, with three nations participating and has

since expanded to include 22 countries. The program calls for reporting via ship's radio of bathythermograph data collected at sea to be relayed via the Global Telecommunication System to those countries requesting the data. The Pilot Project activity is being changed to a fully operational status in June 1975. BATHY data are used in making ocean thermal structure analyses and in determining the characteristics of special phenomena such as the Gulf Stream.

The second Pilot Project of the IGOSS Program is the Marine Pollution Monitoring (Petroleum) Pilot Project (fig. 39). At its Eighth Session in November 1973, IOC endorsed the Pilot Project on Marine Pollution Monitoring within the framework of IGOSS. The member states were requested to give details of their interest and contributions toward the development and implementation of the Pilot Project and to designate national coordinators.

The Pilot Project is conceived as a valid test of the ability of IGOSS participants and the Program to respond to a need for specific data. The ultimate goal is to monitor marine pollution from petroleum hydrocarbon residues to obtain a picture of their distribution and dynamics on a global scale. It is not intended to be an all-embracing or comprehensive marine monitoring program, but one dealing specifically with petroleum. It is designed to be amenable to monitoring and baseline studies and yet not be beyond the capability of a number of developing countries.

The program is to monitor:

- Oil slicks and floating pollutants
- Floating particulate petroleum residues or "tar balls"
- Tar on beaches
- Dissolved petroleum hydrocarbons in the surface waters of the ocean



Figure 39.—Ocean areas included in IGOSS pollution monitoring project.

The major thrust of the program will be in the following areas:

- The North Atlantic Ocean, including a tropical region
- The Caribbean, the North Sea, the Mediterranean Sea, and the Gulf of St. Lawrence
- The Norwegian Sea and the Barents Sea
- The oil tanker route from the Arabian Sea around the Cape of Good Hope to Europe and the route from the Arabian Sea to Japan
- A relatively "clean" area off the west coast of South America

To carry out the Pilot Project, complementary environmental information is needed, such as sea and air temperature, wind speed and direction, salinity, dissolved oxygen and hydrogen, current speed and direction, and wave periods and heights.

The Project is to draw on IOC's International Coordination Group for the Global Investigation of Pollution in the Marine Environment (GIPME) for additional scientific advice needed to further implement the project.

The IOC Working Committee on Training, Education, and Mutual Assistance (TEMA) was designated to assist in any training needs for developing countries with regard to marine pollution monitoring.

Global Investigation of Pollution in the Marine Environment (GIPME)

Since the fiscal year 1975 Federal Plan for MAREP was published, the United States has increased its involvement in planning IOC's Long-Term and Expanded Pro-

gram of Oceanic Exploration and Research (LEPOR), particularly with reference to pollution and process-oriented studies. Global Investigation of Pollution in the Marine Environment (GIPME), largely still in the planning stage, is one major area of our involvement. GIPME is viewed as an adjunct to and an expansion of our marine environmental quality studies and relates to such U.S. programs as Marine Ecosystem Analysis (MESA), the Geochemical Ocean Sections Study (GEOSECS), and the Controlled Ecosystem Pollution Experiment (CEPEX); the last two being organized within the framework of the International Decade of Ocean Exploration (IDOE), wherein several other nations are working with the U.S. The lead agency for coordinating U.S. participation in the GIPME program is NOAA, Department of Commerce. The National Science Foundation coordinates IDOE.

At its Eighth Session, IOC recognized the potential dangers which the accelerating rate of pollution is posing to the marine environment and urged an acceleration of work on a Comprehensive Plan for GIPME. The Commission called for the Plan to provide an appropriate framework for promoting and guiding the scientific research essential to the solution of the complex problems of marine pollution. It must insure the GIPME is implemented to provide for adequate evaluation and monitoring of marine pollution. It must also:

- Identify the technical and material needs for each region
- Identify the training and organizational needs for each region
- Provide for standardization and calibration of instruments and analytical techniques

For one project of GIPME entitled "Pollution of the Oceans Originating on Land (POOL)," a group of experts chose two contaminants, total DDT and PCBs, as test cases. Both are known to have become very widespread and are of major ecological importance. Since the methods of analysis for determining both are similar, it was decided to deal with both at one time. These contaminants are transported through the atmosphere, in discharges from rivers and streams, in terrestrial runoff from land, in seepage from land directly to the sea below the surface, and in effluent pipeline discharges which include domestic and industrial wastes.

The IOC International Coordinating Group (ICG) for GIPME, meeting in New York in July 1974, produced a Comprehensive Plan based on the work of a consultant and the group of experts on POOL. The first priority of the Plan was implementation of baseline studies along with monitoring programs. Zones suggested by the POOL group, namely open oceans, estuaries, and semienclosed seas, were used in the Plan. Components of a research program to evaluate the effects of pollutants must include the determination of acceptable risks for man and the long-term effects of pollutants on the stability of marine ecosystems, such as the effect of the long-term exposure of marine organisms to low levels of pollutants.

IOC expects to work closely with the International Council for Exploration of the Sea (ICES). ICES recently published a report of its work on pollution of the North Sea which included a baseline study. In collaboration with the Scientific Committee on Ocean Research (SCOR), ICES is organizing another baseline study in the Baltic Sea. Future studies are planned for the Northeast Atlantic Ocean in the North East Atlantic Fisheries Commission (NEAFC) area. ICES is also concerned with promoting research and investigations for a study of the North Atlantic Ocean. The United States joined ICES in 1973 and is participating in the working groups concerned with environmental research and monitoring.

Study of "El Nino"

At its Eighth Session, IOC addressed the harmful economic consequences and the complex nature of the multidisciplinary phenomenon known as "El Nino" off the west coast of South Africa. "El Nino" affects the ecology and, in particular, the marketable resources of the marine environment and the climate of the coastline of the countries of the eastern Pacific. This in turn affects the fisheries and the economy of the countries in the area. Therefore, a scientific workshop was organized in December 1974 to evaluate the existing knowledge of "El Nino"; identify key questions that must be answered before the phenomenon can be understood sufficiently or predicted; devise a cooperative research program with the participation of interested coastal countries; and then formulate proposals for a cooperative study of "El Nino" and the biological resources for the region.

Other explorations of ocean circulation mechanisms

and air-sea interaction, also important to improved weather and climate prediction, are being planned to begin in 1976 under the International Decade of Ocean Exploration (IDOE). The lead agency for coordinating U.S. participation in "El Nino" study and other IDOE studies is the National Science Foundation.

International Southern Ocean Study

United States scientists are also involved in designing a pilot drifting buoy experiment to be conducted in the southern ocean. Relative to the First GARP Global Experiment (FGGE) objective, scientists of South Africa, Australia, and the United States hope to obtain valuable information on atmospheric pressure and sea surface temperature conditions of the southern ocean. The program will deploy a number of drifting buoys (23 planned) equipped with a communications capability compatible with the Nimbus F satellite system. The project is scheduled to begin in January or February of 1976. The experiment will be performed in three major areas: off New Zealand, in the Drake Passage, and off the tip of South Africa. For this study, as a component of the International Southern Oceans Study (ISOS), the National Science Foundation, as lead agency, will fund six buoys in the Drake Passage.

United Nations Environment Program (UNEP)

The second session of the Governing Council of the United Nations Environment Program (UNEP) met in April 1974. The Council adopted an action-oriented program which included six areas of special priority, "Oceans" being one of the six. The broad-spectrum action plan emphasizes the necessity of coordinating the numerous activities being carried out by other nations' agencies in the marine environmental field. Lead agency for coordination of U.S. participation in UNEP is the State Department, with other Federal agencies involved via the Committee on International Environmental Affairs, chaired by State.

Special priority is given in UNEP to regional activities, with the establishment of marine pollution program activity centers in the Mediterranean being an initial thrust of the program. Similar programs will be planned for the Caribbean, the Baltic, the Persian Gulf, the Indonesian and Philippines archipelagoes, and parts of the Atlantic and Pacific Oceans.

The UNEP Council encouraged and supported the preparation of regional agreements for the protection of specific bodies of water from pollution, especially pollution from land-based sources. It gave special emphasis to the protection of living resources in the Mediterranean. In connection with this, the Council asked the Food and Agricultural Organization (FAO) to implement its survey of living marine resources called for by the U.N. General Assembly.

Earthwatch

EARTHWATCH is an important functional task of UNEP. It is a global environmental assessment program which includes monitoring, exchange of information, and research. Within EARTHWATCH there are components to assess the impact of pollutants upon the environment, the impact of the environment on man, and to give early warning of potential hazards so that corrective measures can be taken.

The Governing Council of UNEP approved the framework for the Global Environmental Monitoring System (GEMS) that was set up by the intergovernmental meeting on monitoring in Nairobi, Kenya, in February 1974. GEMS is a coordinated effort on the part of member states, United Nations agencies, and UNEP to ensure that data on environmental variables are collected in an orderly and effective manner for the purpose of giving a quantitative picture of the state of the environment and of natural and manmade global and regional trends of critical environmental variables, thereby providing one of the tools required by environmental management at the national and international levels.

A major function within EARTHWATCH is the International Referral System (IRS). It provides a means by which member states can exchange information on the monitoring, assessments, and studies that have been made in order to determine whether their data are comparable to those collected for the same purpose in other countries.

U.S.-U.S.S.R. Cooperation

The bilateral agreement between the United States and the Soviet Union, signed in 1973, provides for a cooperative research effort in studying the world's oceans.

This will involve specification of marine environmental instrumentation standards, calibration procedures, and test facility comparability acceptable to both countries. At the first meeting of the U.S.-U.S.S.R. Joint Committee of the World Ocean Studies, held in February 1974, the two countries agreed to exchange draft lists of equipment prior to August 1974. This was to be followed by a determination of the characteristics of the equipment and comparison of these characteristics with their corresponding standards of calibration.

The Joint Committee also identified other areas for cooperation including large-scale ocean-atmosphere interaction, ocean dynamics, geology and geophysics, biology, and chemistry. Lead agency for coordinating U.S. participation in this cooperative study of the world ocean is NOAA. Strong support is provided by NSF and ONR personnel who chair three of the panels.

Scientists from the United States and the Soviet Union have met three times during the past year to formulate plans for the Large-scale Mid-ocean Dynamics Experiment (POLYMODE). Although all plans are still tentative, the experiment is being organized to cover a 4-year period, culminating in the complete involvement of both the United States and the Soviet Union throughout 1977.

The experiment will consist of three major components:

- Current and temperature measurements from moored stations
- Surveys from ships and by other means
- Observations with Sound Fixing and Ranging (SOFAR) floats

These studies are designed to improve understanding of ocean circulation dynamics.

Summary of Fiscal Data

MAREP funds used by Government agencies in support of operational MAREP services and research to improve MAREP services are detailed below and are reported fiscal year 1975 and proposed fiscal year 1976 budget levels. Many services are also applicable to marine meteorology and are discussed as The Marine Meteorological Service in the annual *Federal Plan for Meteorological Services and Supporting Research*. Some activities of this service, however, are also pertinent to MAREP services and are included as part of this Plan where relevant. The total Government expenditure designated for MAREP in fiscal year 1975 was \$270,908,000. This is \$1,168,000 less than the projected fiscal year 1975 level reported in the fiscal year 1975 Federal Plan (table 10). The planned fiscal year 1976 budget level is \$315,935,000 (table 10), an increase of \$45,027,000 over the actual 1975 expenditures.

Primary increases in MAREP expenditures are carried by the Department of Interior through their activities on the outer Continental Shelf. Department of Commerce also showed increases through the reactivation of research vessels, support for geostationary satellites, and expanded resource surveys. The National Science Foundation increased their Arctic Research Program.

Funding levels by individual agencies for fiscal years 1975-76 are listed in table 11. Most increases reflect increased service products and research; others, as well as fractions of all, are due to the impact of inflation (on MAREP expenditures by Federal agencies.) Table 10 depicts the real per capita MAREP expenditures (in 1975 dollars adjusted for increases due to inflation and population) increasing from \$0.87 per capita in fiscal year 1971 to \$1.28 per capita in fiscal year 1975, an increase of 47% during the 5-year period. Projected fiscal year 1976 levels will yield \$1.33 per capita expenditures, an increase

Table 10.—Total and per capita MAREP expenditures [Adjusted to 1975 values for inflation¹ and population increases]

Fiscal year	Total	Per capita expenditures
1971	\$125,391,000	\$0.87
1972	189,024,000	1.21
1973	193,100,000	1.13
1974	230,856,000	1.21
1975	270,908,000	1.27
1976	² 315,935,000	1.33

¹ Adjustments are made for inflation by applying a price deflator index (Survey of Current Business, Bureau of Economic Analysis, U.S. Department of Commerce).

² Projected.

of 52% since 1971. This increase is almost totally due to the addition of environmental quality programs. Total MAREP funds spent during the same 5-year interval increased from \$145,197,000 to \$270,908,000, an increase of 87%. The \$315,935,000 projected for fiscal year 1976 is an increase of 118% over the 1971 level. Of the \$125,711,000 increase from fiscal year 1971 to 1975, 40% or \$50,284,400 were absorbed by rising costs due to inflation and \$75,426,600 (in 1975 dollars) spent on actual increases in MAREP services and supporting research. Projected fiscal year 1976 funding would provide a \$170,738,000 5-year increase (1971-76), with 66% being absorbed by inflation and only 34% or \$58,050,000 providing new per capita services.

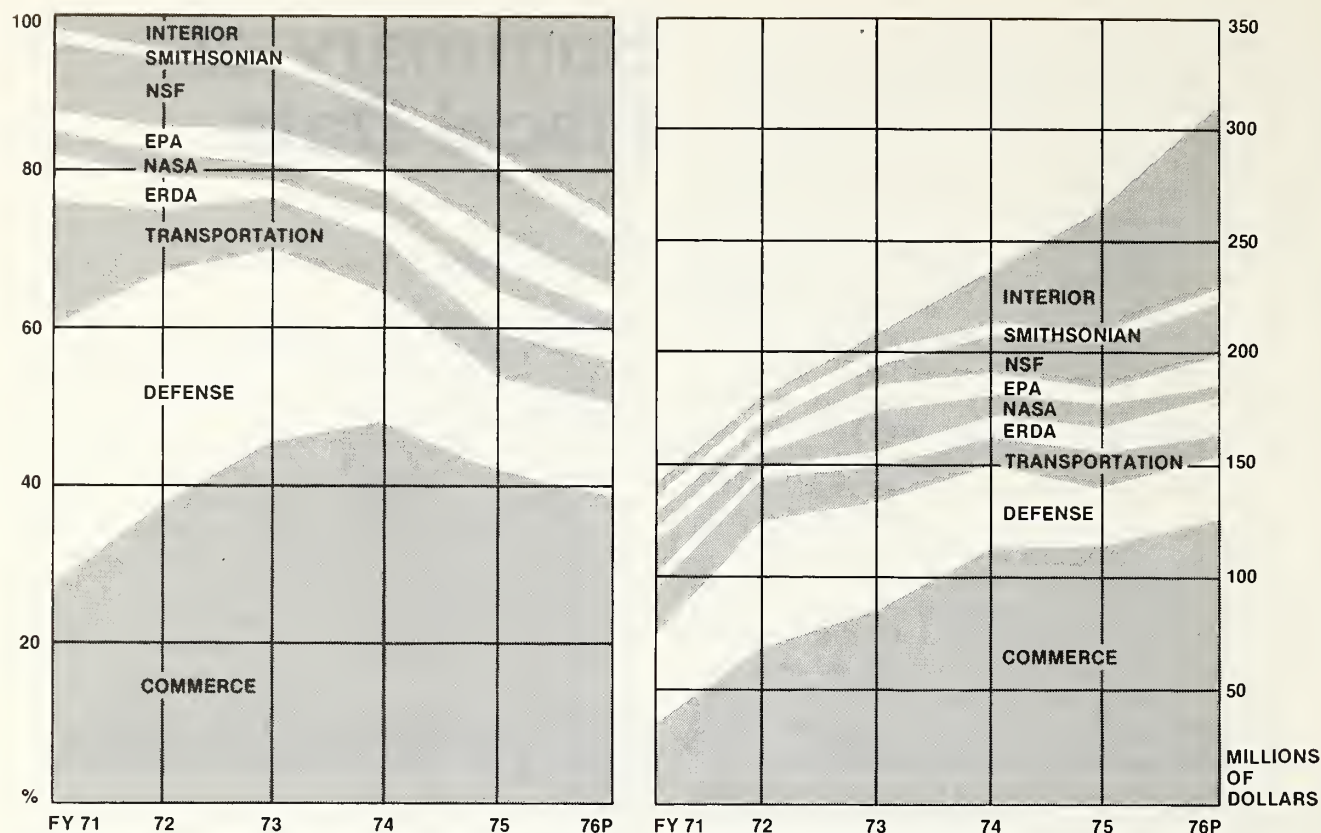


Figure 40.—Total and percent of total MAREP funds by department or agency, 1971–76.

Figure 40 depicts the changes in MAREP funding in terms of total funds and percentage by Department or agency during the 5-year period 1971–76. Relative to the total funding only Commerce, Defense, and Interior exhibit any major changes during the 5-year period. Commerce (NOAA) shows a gradual but constant increase through fiscal year 1974, reflecting NOAA's conception and growth. The Defense Department, primarily Navy interests, shows a constant decline after fiscal year 1974, a result of Navy reprogramming toward more mission-oriented research and operations. The most dramatic change is shown by Interior as their funding base has expanded rapidly since fiscal year 1974. Service area increases by agency from fiscal year 1975 to 1976 are shown in table 12.

Operational expenditures for MAREP by function are shown in table 13. Major increases are shown by Commerce and Interior, whereas decreases are apparent in the Defense budget. Manpower engaged in these operational activities is summarized in table 14. Only Interior shows a substantial increase in manpower, concurrent with its

increases in funding. A major decrease in manpower allocation to Data Acquisition by the Department of Transportation despite level funding is also shown. Expenditures for research are shown in table 15; major increases are shown for Interior, Commerce, and NSF.

The most significant trends are found in the redirection of national MAREP goals. In 1971, when ICMAREP was formed, the Department of Defense reported the largest percentage of MAREP funding (32%), followed by Commerce (NOAA) (28%). From 1971 through 1973 funding for the other member agencies remained essentially level, with only Commerce (NOAA) showing major increases (1973:46%). Decreases by Defense after 1973, essentially level funding by Commerce, and major increases by Interior are reflected by the growing concern and redirection of priorities toward energy exploration on the outer Continental Shelf. Projected 1976 percentages show Defense providing only minor MAREP support (10%), Commerce down slightly to 41%, and Interior continuing its expansion to 28% (from 3% in 1971).

Table 11.—Federal funding for Marine Environmental Prediction, by agency
[Thousands of dollars]

Agency	Operations			Research			Total	
	FY 75	FY 76	Difference	FY 75	FY 76	Difference	FY 75	FY 76
Commerce	64,396	71,902	+ 7,506	52,877.2	56,405.2	+ 3,528	11,727.2	128,307.2
Defense	16,237	15,815	— 422	13,719	14,269	+ 550	29,956	30,086
Interior	11,546	15,955	+ 4,409	43,904	69,263	+25,359	55,450	85,218
Transportation	12,288	12,714	+ 426	2,965	3,175	+ 210	15,253	15,889
EPA	6,724	6,388	— 336	4,833	5,075	+ 242	11,557	11,463
ERDA				12,912	14,000	+ 1,088	12,912	14,000
NASA				4,188	4,053	— 135	4,188	4,053
NSF				21,200	23,800	+ 2,600	21,200	23,800
Smithsonian	1,362	1,362		1,757	1,757		3,119	3,119
Total	112,553	124,136	+11,583	158,355.2	191,797	+33,442	270,908.2	315,935
								+45,027

Table 12.—Federal funding for Marine Environmental Prediction, by Service
[Thousands of dollars]

Service	Operations			Research			Total	
	FY 75	FY 76	Difference	FY 75	FY 76	Difference	FY 75	FY 76
Basic	63,017	69,036.9	+ 6,019.9	121,759.2	148,127.2	+26,368	184,776.2	217,164.1
Maritime Commerce	8,014.5	7,870	— 144.5	1,566	1,883	+ 317	9,580.5	9,753
Water Quality Assessment	18,220	22,444	+ 4,224	12,275	17,283	+ 5,007	30,495	39,727
Living Marine Resources	9,538	11,417	+ 1,879	13,122	14,841	+ 1,719	22,660	26,258
National Security	13,853	13,460	— 393	7,910	8,450	+ 540	21,763	21,910
Total	112,642.5	124,227.9	+11,585.4	156,632.2	190,584.2	+33,951	269,274.7	314,812.1
								+45,177.4

Table 13.—Agency operational expenditures for Marine Environmental Prediction, by agency
[Thousands of dollars]

Agency	Data acquisition			Communi- cations			Data processing			Information dissemination			General agency support			Total	
	FY 75	FY 76	FY 75	FY 76	FY 75	FY 76	FY 75	FY 76	FY 75	FY 76	FY 75	FY 76	FY 75	FY 76	FY 75	FY 76	Difference
Commerce	30,600	36,203	874	874	10,762	11,549	9,034.5	9,316.5	6,656	6,588	57,926.5	64,530.5	+	6,604			
Defense	8,936	8,499	969	980	2,415	2,311	1,685	1,727	2,232	2,300	16,237	15,817	—	420			
Interior	6,928	9,573	115	160	2,193	3,030	1,155	1,596	1,155	1,596	11,546	15,955	+	4,409			
Transportation	10,304	10,467	208	222	814	863	252	260	668	859	12,246	12,671	+	425			
EPA	(*)		(*)		(*)		(*)		(*)		6,724	6,388	—	336			
Smithsonian	869	869					293	293	200	200	1,362	1,362					
Total	57,637	65,611	2,166	2,236	16,184	17,753	12,419	13,192	10,911	11,543	106,041	116,723	+	10,682			

* No breakdown available.

Table 14.—Agency manpower engaged in Marine Environmental Prediction Operations, by function
[Man-years]

Agency	Data acquisition			Communi- cations			Data processing			Information dissemination			General agency support			Total	
	FY 75	FY 76	FY 75	FY 76	FY 75	FY 76	FY 75	FY 76	FY 75	FY 76	FY 75	FY 76	FY 75	FY 76	FY 75	FY 76	Difference
Commerce	558	563	15	15	335	335	280	284	182	182	1,370	1,383	+	13			
Defense	264	240	60	59	167	159	136	135	110	109	737	702	—	35			
Interior	230	320	4	5	73	101	39	53	39	53	385	532	+	147			
Transportation	799	652	16	16	68	68	13	13	53	53	929	802	—	127			
EPA	(*)		(*)		(*)		(*)		(*)		36	34	—	2			
Smithsonian	63	63					12	12	7	7	82	82					
Total	1,894	1,838	95	95	643	667	480	497	391	404	3,849	3,535	—	4			

* No breakdown available.

Table 15.—Agency funding for research to improve Marine Environmental Prediction functions
[Thousands of dollars]

Agency	Understanding basic processes		Data acquisition		Communi-cations		Data processing		Information dissemination		Agency support of research		Total	
	FY 75	FY 76	FY 75	FY 76	FY 75	FY 76	FY 75	FY 76	FY 75	FY 76	FY 75	FY 76	FY 75	FY 76
Commerce	28,002	30,642	19,209	17,921			3,938	3,938	421	421	3,385	3,640	54,955	56,562
Defense	6,434	6,519	5,212	5,502	576	601	1,239	1,284	258	363			13,719	14,269
Interior	17,649	27,843	8,693	13,714	439	693	8,343	13,161	4,390	6,926	4,390	6,926	43,904	69,263
Transportation	1,186	1,270	1,483	1,588							296	317	2,965	3,176
ERDA	12,912	14,000											12,912	14,000
EPA	4,833	5,075											4,833	5,075
NASA			4,188	4,053									4,188	4,053
NSF	21,200	23,800											21,200	23,800
Smithsonian	1,757	1,757											1,757	1,757
Total	93,973	110,906	38,785	42,778	1,015	1,294	13,520	18,383	5,069	7,710	8,071	10,883	160,433	191,955
														+31,533

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